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contents

June & July 2007

Courtesy Darren Anderson

Courtesy www.dcpower-systems.com

Courtesy William Miller

Courtesy Eben Fodor

On the Cover

Debra Galandzy and Doug Horn behind the grid-tied PV array that meets all of their annual electricity needs. See page 26.

Photo by www.joshroot.com

Courtesy Molly Loomis

Courtesy Walt Ratterman

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Regulars

from us *to you*

The Solar-Electric End Game

Andrew Davidson

Renewable energy advocates like us tend to stare enviously across the ocean at the great success and widespread adoption of solar electricity abroad. But we're not sitting on the bench, scratching our heads, and wondering how they're doing it. The governments of countries like Germany and Japan have put more than sound bites behind their support for clean energy technologies. Instead, they have established well-coordinated incentive programs and interconnection standards for solar energy at the federal level.

The solar policy landscape in the United States has been haphazard and fragmented by comparison. Because of the nearly complete absence of federal, top-down leadership, legislative efforts focused on interconnection and billing standards for solar-electric systems have been sidelined to the state level, creating inconsistencies, anomalies, and unnecessary redundancy in the efforts of solar policy developers.

However slow on the uptake, Congress now appears to be entering the game. Not only is the much-celebrated federal solar tax incentive up for an eight-year extension (visit www.seia.org to register your support), but legislators have finally drafted a national solar energy bill aimed at stripping several barriers to the widespread adoption of solar-electric generation.

Major provisions of the proposed Solar Opportunity and Local Access Rights (SOLAR) Act:

- Establish net metering at retail electric rates for customer-owned, grid-tied solar-electric systems up to 2 megawatts (MW).
- Designate customer ownership of any renewable energy credits (RECs) generated by the installed system.
- Prohibit any private covenant, contract or lease provision, or homeowners' association rule or bylaw from limiting a homeowner's ability to install a solar energy system.
- Specify maximum permitting and licensing fees for both residential and commercial installations.

Many nations worldwide have come up hard against energy resource constraints and the impact unrestrained fossil fuel use has on the local (and global) environment. We need strong and coordinated federal leadership when it comes to renewable energy generation. Only this will allow us to begin to close the gap between the lagging solar energy programs stateside and the experience that has been gained by energy progressive nations abroad. Fortunately, there's a tangible shift underway in Congress, and many of our representatives are ready to run with legislation that supports clean energy, and puts us back on the global solar playing field.

Act On It...

Find and contact your congressional reps at www.usa.gov/Contact.shtml and make sure they support the Solar Opportunity and Local Access Rights (SOLAR) Act introduced by Senator Menendez (NJ) and Representatives Cardoza (CA) and Ferguson (NJ).

home power

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Ask the EXPERTS!

PV String Sizing

How do I decide how many modules to wire in series for a batteryless, grid-tie inverter? It all seems very complicated—is there any way to simplify my design decision?

John Worth • Plainview, Texas

String sizing for grid-tie inverters involves optimizing several—often conflicting—performance and safety design factors. I can't fully explore all the issues involved in just a few paragraphs, though I can identify the issues and steer you to the right tools. But first I'm obliged to mention that DC voltage in the 100 to 600 V range is dangerous stuff and best left to a professional.

It boils down to choosing a string size that meets three very important parameters, while trying to optimize a few more. You must satisfy a voltage window that, on the high end, is limited by the maximum open-circuit voltage that the inverter can handle before you harm its electronics and, on the low end, is limited by two factors—the minimum MPPT voltage that the inverter can operate at and the minimum start-up voltage the inverter needs. While doing that, you also have to feed the inverter enough wattage to ensure you are using the inverter efficiently while not feeding so much that you overpower it. You also have to stay within the inverter's amperage limits while keeping voltage drop to a minimum.

All these parameters are moving targets because PV module output is inherently temperature dependent, with cold and hot weather performance varying greatly. So you see that you were right—it is complicated! However, there are two tools I would recommend you use.

The first tool is a string-sizing calculator or chart that inverter manufacturers make available on their Web sites. Start with the inverter model, module make and type, and the critical inputs of the average highest temperature at your site and historical absolute lowest temperature the array will ever experience under sunlit conditions. The calculator results will show the allowable and ideal string-sizing combinations.

Courtesy www.xantrex.com

Sample inverter string-sizing online calculator.

The second tool is a solar professional. Though the string-sizing tools are good, they can't make all of the critical decisions that go into good solar-electric system design. The safety issues are just too important, so at the very least, you should have a pro evaluate your intended design, and then seriously consider having a pro install your system too.

Jeff Clearwater • Village Power Design

Exercise Energy

My teenage son and I work out on either our rowing machine or elliptical trainer six days a week. Between the two of us, we put in 1.5 to 2 hours of intense physical activity—energy. Is there any way that I can convert the energy that we expend on our exercise equipment into electricity to store in a bank of batteries? It would be really cool to use all this human-made energy to, say, power our water heater.

Marcia Anderson • Fairview, Pennsylvania

While I would love to see all exercise equipment set up to generate electricity, we need to be realistic about the potential. An adult in good shape can generate about 75 watts continuous. This I know from experience on several different bike generators—manufacturers' claims to the contrary.

If you put in two hours per day between the two of you, that amounts to 150 watt-hours at best. Let's assume that you are superhuman, and round it up to 200 watt-hours per day. Six days a week gives you 1.2 kilowatt-hours (KWH) per week, and if you never go on vacation, that's 62.4 KWH per year. If electricity costs $0.15 per KWH in your area, you will have offset less than $10 worth of electricity per year—not much of a dent in your water-heating bill.

(continued on page 14)

Now appearing in backyards everywhere.
Small wind has never been so easy. Announcing the Skystream 3.7™ residential power appliance. It's the first compact, utility-connected, all-inclusive wind generator designed to provide inexpensive, quiet, clean electricity to reduce or eliminate your home's monthly energy bill. Learn if Skystream can work for you at www.skystreamenergy.com.
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The investment in setting yourselves up for a pedal generator will not be insignificant. I've seen home-brew rigs that cost less than $50, and a bunch of the owner's time. Manufactured units can cost $500 or more. For almost the same price, you can buy a 100-watt PV module that, in full sun, will produce abut the same amount of energy as you can, but over a much longer period of time (as often and as long as the sun shines)!

Americans have lots of toys and tools, and having toys and tools that produce energy and lighten our impact on the planet is all to the good. We just need to be realistic about our expectations, and about our commitment to getting on the exercise machine. On a sailboat or in a small cabin, a pedal generator *might* make a real impact on the energy budget. But for most normal American homes, it's a drop in the bucket.

Ian Woofenden • *Home Power*

Courtesy www.abundantre.com

Wireless Networks & Wind Generators

Is it possible to combine the use of a wind generator tower with wireless Internet equipment? A local Internet broadcasting business approached me about putting up a tower on my land for their wireless transmitter. I've been wanting a wind turbine for some time. Would I be able to put both of these items onto one tower? I told the owner that my wind turbine would have to be at the top, and he was fine with that. If this would work, it would help reduce the cost of my project since he is willing to pay for space on the tower. But I'm wondering if the turbine would create interference to his equipment?

Chuck Schneider • Trimble, Missouri

We have wireless transmission equipment on our 140-foot freestanding tower, on which we are also testing the ARE 442 wind generator. The local wireless Internet company uses our tower as a distribution node in their system. Their equipment is at the 80- to 100-foot level on our tower, and has been working for almost a year with no problem for us or them. One warning: Our tax assessors overlooked the wind equipment on our tax assessment until we got the wireless equipment. Now they are looking at the value of the tower as a commercial structure. That problem should be covered in the agreement with whoever rents your tower space.

Robert Preus • Abundant Renewable Energy

Venting Sealed Batteries

I have four gel-type batteries in a solar-electric system that powers my Sun Frost fridge. How much ventilation is needed for the battery box? Can it be on the sides only? Top and bottom of the sides? Top of the battery and top of the box? Evenly spaced? Is it OK to put holes on the hidden sides only? Do I need more than a fraction of an inch clearance from the outside of the box beside the holes? Thank you very much.

Judy Kosovich • via e-mail

The batteries you are using are sealed (maintenance-free), but you still need to pay attention to proper ventilation. Right out of the gate, be careful not to overcharge sealed gel-cell batteries. Overcharged sealed batteries will be ruined if excess overcharging occurs. Make sure your charge controller has the appropriate charge regulation setpoints based on the battery manufacturer's specifications.

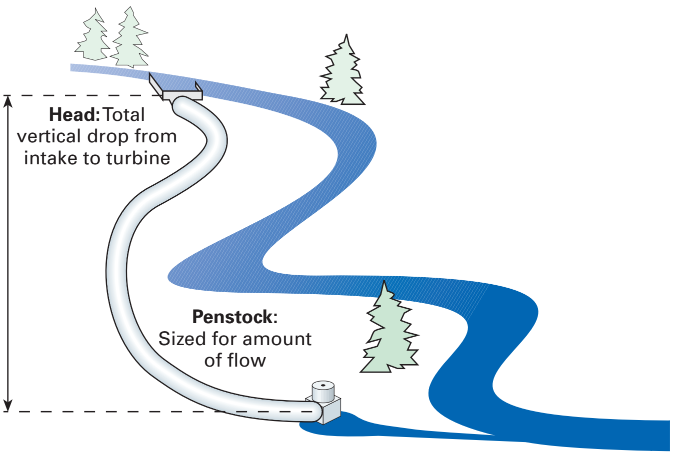
Regarding ventilation of your battery enclosure, while sealed batteries only produce minute amounts of gas during normal operation, they still should be located in a ventilated area like a garage, and never in a living space. This will protect you against the worst-case scenario of substantial gassing that would occur in the overcharging scenario described. The batteries should be installed in either plastic tubs with lids or a wooden enclosure to protect unqualified people from coming into contact with battery terminals or wiring. For more details on the specific ventilation requirements, see the battery enclosure article on page 50 of this issue.

Joe Schwartz • *Home Power*

Hydro Potential

I have a stream on my property, and I'm wondering how to approach developing it for hydro-electricity. How do I know how much potential I have? What should I do first?

Bev Almond • Jonesville, North Carolina



You need to examine three aspects when considering a small hydro-electric project:

Mechanical. First, you must measure two critical things: *head* (the vertical drop from intake to discharge) and *flow* (water volume available—minimum and maximum), measured in gallons per minute. To estimate the site's power potential, simply multiply the head by the flow, and divide that number by 10 or 12. (This formula works well for measurements above 50 feet of head and 30 gpm.) The result will be the approximate average potential (in watts) from the site. If you try to cut costs on pipe or wire size, you'll reduce that potential.

Next, you'll need to figure the length of the penstock (pipe) and the wire transmission length. These two concerns are mostly economic, but they can also affect system efficiency.

Environmental. Can an intake (diversion) be constructed that addresses environmental concerns, such as fish passage and not drying out the creek? The answer for home-scale hydro is almost always yes due to its scale. Most people have an interest in caring for the stream ecology, but occasionally some don't or won't, which leads us to…

Political. Every state seems to have different water laws and permit processes. Some states do not have any restrictions. You'll need to contact state and local authorities to find out what permits you'll need, if any.

If your investigation of these three areas leads you to believe that you have a viable resource, I hope you will pursue it. Small-scale hydro-electric systems can be a very satisfying and cost-effective way to generate electricity sustainably.

Jerry Ostermeier • Alternative Power & Machine

Starting a Ride-Share Program

I'm tired of seeing everyone in my suburban community pull out of their driveways each morning, moving two or three thousand pounds of steel and plastic across the city to go to work. I want to *do* something about it—perhaps organizing a community ride-share program is an answer. How do I get started?

John Shalberg • Glendale, Ohio

Many communities already have ride-sharing programs set up, and can be found by plugging "ride-share" or "carpool" and your community's name into your favorite Web search engine. Aside from the obvious reason of saving fuel (and money), here are a couple more benefits to taking part in a ride-share program:

- You can ride in HOV (high occupancy vehicle) lanes on the highway, which will probably reduce your commuting time.
- Assuming you're on a schedule that rotates drivers, you'll be able to kick back, relax, and let someone else do the driving.
- Since you'll be driving your car less, you'll reduce the wear and tear on your vehicle and extend its life.
- You get some "bonding time" with your co-workers or neighbors.

Here are some simple and easy ways you can go about getting others to participate:

- Contact your employer's human resources department and let them know you are interested in starting a carpool program.
- Leave a note in the lunchroom or on the company bulletin board letting people know about the potential program and to contact you if they are interested.
- Write an article for the company newsletter stating your interest in creating a ride-share program, why people should participate, and to contact you if they are interested or have questions.
- Post notices on bulletin boards in your community, and talk with your neighbors.

Once you've recruited a whole bunch of interested people, organize carpooling groups of three to four people based on their geographic proximity. Driving too many extra miles to pick someone up defeats the point of carpooling. Once you've determined carpooling groups, develop a driving schedule. For example, each person in the group drives during a certain week of each month. Give it a try—I think you'll be surprised by the response you'll receive.

Brian Carr • www.dailyfueleconomytip.com

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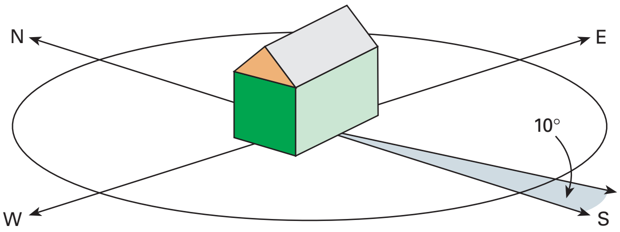
Mailbox

Passive Solar Orientation

In Debra Coleman's article "Designing Your Place in the Sun" in *HP116*, she advises to "seek summer shade." In this era of global warming and in my temperate North Carolina climate, overheating is a real concern. On this subject, Ms. Coleman states, "a slight easterly rotation can help." Solar engineers are usually facing south and for them an easterly rotation would be counterclockwise or to the left. I've nearly convinced myself that is what Ms. Coleman means, but want to be sure before the footings go in. Thanks,

Ross Henderson • Hickory, North Carolina



House layout is certainly something you want to make sure you understand prior to pouring footings! It is possible to become confused as to whether or not the recommended 10-degree easterly orientation applies to the south side. Your counterclockwise reference is right on target as one of the best ways to reference the 10 degrees eastern orientation.

Don't forget to first find true south, as was mentioned in the same issue of *Home Power* on pages 12 and 13. The map that Richard Perez included gave an overview of the magnetic declination for the United States. My article mentioned the following link as another way to determine the magnetic declination for your location: www.ngdc.noaa.gov/seg/geomag/jsp/Declination.jsp. It allows you to determine the correct declination for your location based on your zip code.

Here is one clause directly from Sun Plans specs: "If the declination shows west, then rotate the house clockwise that many degrees from magnetic north as the compass shows; if the declination is east, then rotate the house counterclockwise that many degrees." To address cooling concerns and minimize afternoon overheating year-round, you would then make the additional counterclockwise adjustment for the 10-degree easterly orientation.

Debbie Coleman • Sun Plans Inc.

"Though falling water is a much better energy choice than coal, petroleum, or atom-splitting, we still have a responsibility to tap it carefully, and with other species in mind."

Hydro Impact

In the "Microhydro-Electric Systems Simplified" article in *HP117*, one thing was missing. Whether micro or mega, hydro-electric impoundments are good for the environment if a bypass is part of the design. Hydro-electricity is renewable and sustainable. When a bypass is included, the facility enhances wildlife habitat in many ways. Additionally, ground water is recharged. Conversely, failure to allow for upstream and downstream aquatic life passage is a negative. Please include bypass discussion in your future articles on hydro-electricity.

Ken Burchesky • Lyndonville, Vermont

We should definitely minimize impact on streams when we tap them for hydro-electricity. Though falling water is a much better energy choice than coal, petroleum, or atom splitting, we still have a responsibility to tap it carefully, and with other species in mind.

Even small-scale microhydro-electric projects can have ecological impacts depending on their design. Small projects that mimic large-scale projects can result in intrusive, expensive dams that disrupt the local flora and fauna and the watershed. My conclusion is that in many cases, impoundment ponds aren't necessary at all. Instead, simply diverting a small portion of the stream with an unobtrusive and inconspicuous self-cleaning screen built into a carefully chosen spot in the existing streambed can suffice.

Ian Woofenden • *Home Power*

In My Backyard

There is an interesting juxtaposition on the *From Us to You* page in *HP117*. The title, "Yes, In My Backyard" and the picture suggest we all should be happy to have a 130-turbine commercial wind project placed in our own backyards, industrializing places we hold beautiful and sacred as I do Nantucket Sound. Your message, however, more clearly states that we would do well to accept the placement of individual, home-sized turbines in our actual backyards, a sentiment with which I agree. How could I not—living as I do, off grid in Vermont, with a small turbine and photovoltaic array? I recommend electricity generation plants—and their towers and racks—in domestic settings.


Photo: einbo

The photograph heading your editorial was of wind turbines between Copenhagen and Malmo, Sweden. The setting is not wild, as is that of Nantucket Sound or the ancient ridges of the Appalachian range, but domestic. Clearly seen behind the turbines is a long bridge, the hand of man and his machines, established long before the turbines were added. The location of the turbines there is appropriate. Indeed, as the quote you include states: "Give Americans the facts and they will do the right thing."

Whether grid-tied wind turbines make useful, affordable electricity and especially whether they actually avoid carbon emissions is another matter altogether. Also, we must avoid the knee-jerk, "any technology no matter the cost" reaction to energy generation concerns. There are serious problems with applying a widely and randomly variable energy source to an electrical grid. For example, in distorting itself to accept the power, the base-load electricity providers work

less efficiently, producing more carbon than they otherwise would. Such is not the case, of course, with our off-grid systems.

Because I have worked in renewable energy and have lived off grid for more than two decades, I feel a duty and the privilege to present what I have learned to my community. I did an energy analysis of this home and present the results in a form intended to teach and empower others regarding energy. Turning each energy source we use into the same units, kilowatt-hours in this case, enables us to compare the energy use of each source. While renewable electricity generation is flashy and fun, it is far from the most effective way to address our carbon footprint today.

Critically, regarding carbon emissions, it turns out that we, in our well-insulated Vermont home, use 15 times as much energy heating the home as we use in electricity in a year. (My 55 mpg Geo uses six times as much, traveling 22,000 miles per year—too far, I know, but it's hard to live rurally today and not drive.) But one saves energy at 100 percent efficiency. Improve the insulation of your average American home this year to save a single cord of wood (equivalent to about 10,000 KWH)

> *"Regarding carbon emissions, it turns out that we, in our well-insulated Vermont home, use 15 times as much energy heating the home as we use in electricity in a year."*

and you earn that "free electricity" each year from that point forward—for the rest of the life of the house. For homes heated with oil, such improvements address three issues: carbon loading of the atmosphere, peak oil, and the acquisition of foreign oil (and the sad and dangerous consequences of U.S. hegemony to that end).

"At this point, considering the demand, we need any source of clean energy we can find. Personally, I would choose an economically profitable wind farm in my neighborhood every time over any of the currently available alternatives."

While I think it may be inappropriate for *Home Power* to advise on complex subjects that may be beyond its sphere—such as commercial electricity generation—you would do well to present the balance of energies used in a home to help readers get dialed in regarding what energy sources we use, how much we use of each, and the implications of those uses regarding carbon footprint. Best,

Paul Kenyon • Bridport, Vermont

When I read your editorial in *HP117*, I noticed that near the horizon in the background of the picture, there is a huge highway overpass that seems to cross the sound. Those ugly bridges are just as unnatural and man-made as the offshore wind farm, but apparently people have gotten used to them, because the overpass allows them to cross the sound conveniently in their car at any time without having to wait for a ferry.

In the same way, I hope that people will soon get used to the sight of wind farms, because electricity is a so much more convenient, practical, and precious good than any given strip of asphalt. Ask yourself: Would any person in the eighteenth century Netherlands have complained about the ubiquitous Dutch windmills? Probably not. On the contrary, they were essential for grinding corn and pumping water. People understood that their necessity outweighed any aesthetic concerns. And in my opinion, modern windmills look a whole lot better than those of the past.

We need to look at energy and environmental issues pragmatically. At this point, considering the demand, we need any source of clean energy we can find. Personally, I would choose an economically profitable wind farm in my neighborhood every time over any of the currently available alternatives. My own backyard wind turbines have been running for five years now. Considering

the global climate situation, erecting wind generators can only be wrong in places where they won't see enough wind to be profitable. Keep up the good work!

Bernd Geisler • Denison, Texas

Home Power supports the installation of both residential and commercial-scale renewable energy systems. While residential-scale wind-electric systems can be a good energy source, these small systems have nowhere near the reliability or efficiency of large-scale wind farms. And many Americans live where small-scale wind systems are not viable for a variety of reasons, including resource availability, space requirements, and zoning issues. Industrial-scale wind turbines will play an important role in our renewable energy future.

Of course, wind farms need to be sited intelligently, and they do have some impact. But as Tom Gray of the American Wind Energy Association says, opponents of wind farms tend to compare them to *nothing.* Well, nothing has no impact, but it also makes no energy. When we compare wind farm impacts to the impacts of coal, natural gas, and nuclear generation, we start to get a truer picture of the pros and cons of each energy source, and the effect our energy demand has on the environment and our quality of life. Siting generating plants in our view, water, and airsheds helps us face our personal impact, and bear (and ultimately minimize) its burden.

With regard to concerns of applying widely variable energy sources to the grid, there are some creeping myths about large-scale wind farms, their output variability, and their CO_2 offset. The Bonneville Power Administration and the Northwest Power and Conservation Council recently released the Northwest Wind Integration Action Plan. It states that "there are no fundamental technical barriers to operating 6,000 megawatts of wind in the Pacific Northwest." This level of wind generation capacity is expected to be online by 2019, and will increase the percentage of wind-sourced electricity in the Northwest from 2 to 8 percent, reduce exposure to coal and natural gas price volatility, and displace enough fossil, hydro, and nuclear generation to power an estimated 1.5 million homes.

One of the members of the Technical Working Group's System Operators Committee stated that while 1 megawatt of new wind is more variable and less predictable than 1 megawatt of new load, they also said that "there is nothing about wind energy that is fundamentally different than anything we have been dealing with on the load side for many years."

Joe Schwartz • *Home Power*

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Energy Sma

Efficiency Gains + Solar Electricity

Left: Debra and Doug meet all their electrical energy needs annually with a 1,050-watt PV array.

arts

by Doug Horn

Courtesy Doug Horn

The PV array finds a window of sun through the lush foliage of the Pacific Northwest.

A whole-house efficiency upgrade and a net metering agreement with the local utility allowed homeowners Doug Horn and Debra Galandzy to invest in a solar-electric system that meets all their electricity needs, even in the cloudy Pacific Northwest.

Even though winters in our town of Vancouver, British Columbia, can be wet and dark, that didn't dampen our enthusiasm for solar energy. We had read that there are a number of locations that have solar-electric (photovoltaic; PV) systems producing ample electricity with even less of a solar resource than we have here in BC. With a grid-tied system, our sunny months, from May through September, could compensate for our cloudy ones, lending to good overall annual performance.

But the dream of producing our household electricity with the sun came to a screeching halt when Debra and I found out that the local electrical company did not offer net metering—a program that allows homes or businesses to offset grid electricity use with on-site, RE-generated electricity at the same rate per kilowatt-hour (KWH). We had toyed with the idea of installing an off-grid battery-based system, liberating ourselves completely from the electrical utility, but we knew that batteries would be the weak link in such a system. Most batteries require regular maintenance and all types eventually need replacement. Living in a city that very seldom experiences power outages made a battery-based system seem especially unnecessary. With no financial incentives from the provincial or federal governments, except a sales tax rebate of 6 percent, we needed to minimize system costs as much as possible, and a battery bank would have added significantly to the project's overall expense.

Courtesy Glyn Evans

Although not having net metering meant relegating our grid-tied project to the sidelines, our interest continued. At the same time we were making our PV plans, we purchased a 1,300-square-foot cottage originally built in 1911 in Vancouver's North Shore area, and found ourselves expanding the project to include a whole-house efficiency upgrade. We knew that decreasing a home's energy consumption was a smart first step before purchasing a PV system. Reducing your need for electricity translates into a smaller—and less expensive—PV system. In fact, every dollar you invest in efficiency roughly shaves \$3 to \$5 off system costs.

Doug enlisted help from the Vancouver Renewable Energy Coop during the design and installation of his PV system.

VREC members Rob (white hat) and Mike (orange shirt) provided design support, labor, and oversight for the project.

Courtesy Darren Anderson (2)

Energy Wise Upgrades

The cottage's location made commuting to work or play energy efficient. It is a convenient walk or bike ride to work and essential stores, and the mountains and hiking or biking trails are accessible by foot or pedal. The home had a south-facing roof that looked like it would be well suited for photovoltaic modules. But we had our work cut out for us. The almost-century-old house came with antiquated appliances—a refrigerator, range, and clothes washer and dryer that were all about twenty years old. And the forced-air, natural gas furnace was even older—circa 1960.

Our daily electrical usage was about 14 KWH per day—already about a quarter of what the average Canadian household consumes, and half that of a typical American household. But our goal was to use less than 10 KWH per day, a load which even a relatively small PV system could mostly offset.

During the first year, we replaced all the old, inefficient appliances with new, efficient ones. The simple act of replacing the 15-year-old refrigerator dropped our electricity consumption an average of 3 KWH per day. We bought a new water heater, and gas range and oven, purchased a new clothes dryer, and got a horizontal-axis washing machine that uses less energy and less water. The final big appliance upgrade was replacing the old natural gas furnace with

Energy efficiency upgrades, like this new washer and dryer set, help whittle down household energy use.

Courtesy Doug Horn

Household Energy Consumption

	KWH Per Day (Equivalent)		
Energy Source	Before Upgrades	After Upgrades	Reduction (%)
Electricity	13.7	3.0	78%
Natural gas	63.9	41.7	35%
Totals	77.6	44.7	42%

a 98 percent efficient model. A programmable thermostat for the furnace helps keep home heating bills in check by automatically resetting the temperature setpoints according to planned occupancy times.

We also replaced energy-wasting incandescent lightbulbs with compact fluorescent bulbs, and put the stereo and computer on plug strips to eliminate any phantom loads when they were turned "off." For the washer and dryer, which had digital displays that were phantom loads, we needed to find a slightly better way to shut off the electricity to them after their cycles were finished. We found that the washing and drying times never went beyond an hour, so I installed a 60-minute timer switch. Before using the washer or dryer, we simply give the timer a turn.

Although the efficiency upgrades had a big impact on our energy use, combining them with conservation practices—using a clothesline to dry clothes whenever possible, shutting off lights when we leave a room—improved the savings too. The result? We reduced our average electrical usage by 78 percent—to about 3 KWH per day—and cut our natural gas consumption by one-third. At present electricity and natural gas prices, the energy savings translates into an annual dollar savings of more than Cdn$750, and about 11 years to recoup our investments in appliance upgrades. Of course, as electricity and natural gas rates continue to climb, the savings will grow and the payback time will shrink.

Sizing Up the System

While the efficiency project was in full swing, we kept an eye on the electric utility company, BC Hydro, to see what was

Tech Specs

Overview

System type: Batteryless, grid-tie solar-electric

Location: North Vancouver, BC, Canada

Solar resource: 3.7 average daily peak sun-hours

Production: 88 AC KWH per month average

Utility electricity offset (annually): 100 percent

Photovoltaics

Modules: 6, Sharp NT-175U1, 175 W STC, 35.4 Vmp

Array: One 6-module series string, 1,050 W STC total, 212.4 Vmp

Array AC disconnect: Hubbell, HBL13R90, 30 A breaker

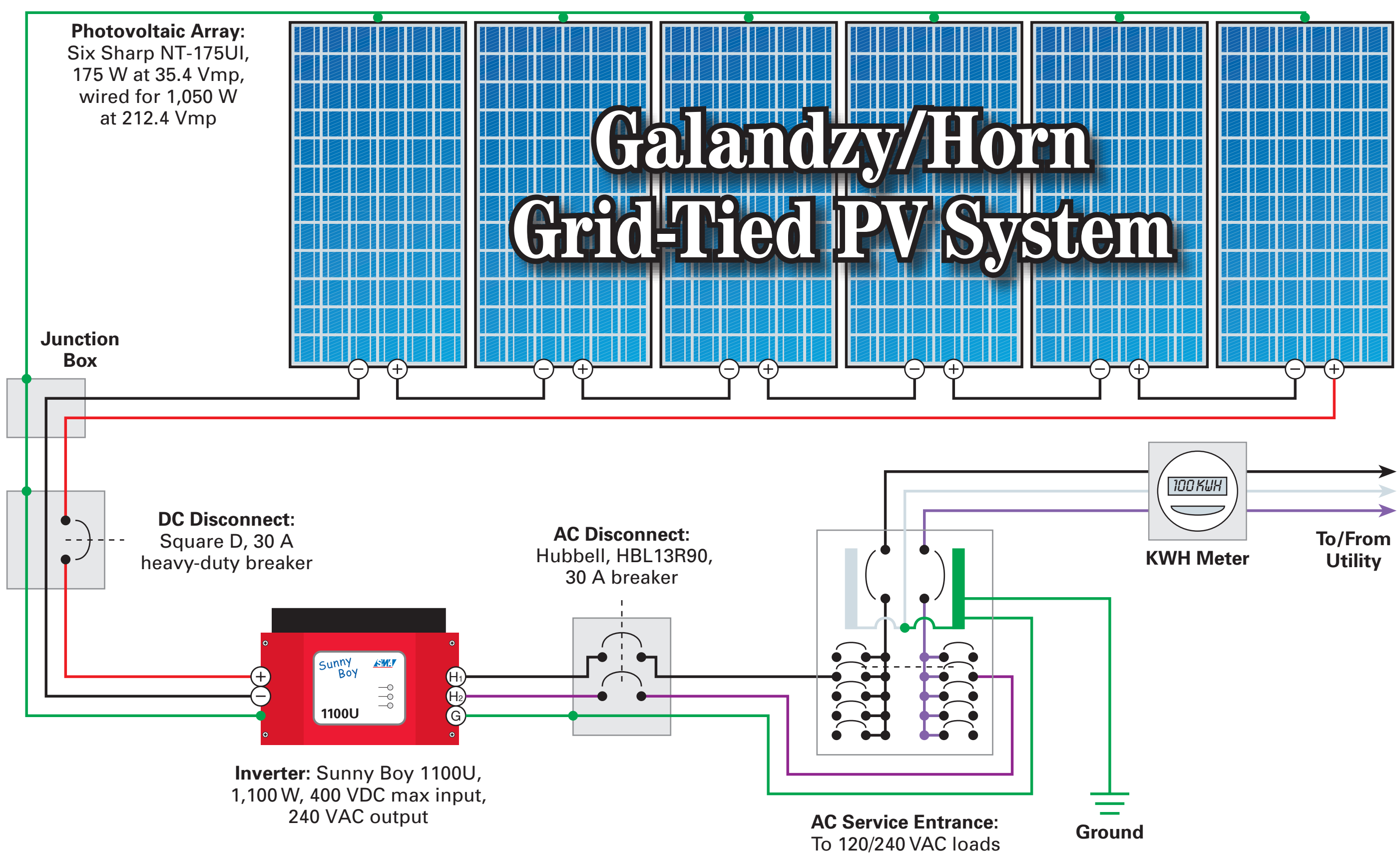
Array DC disconnect: Square D, 30 A, heavy-duty switch/breaker

Array installation: Custom aluminum rack with 6-inch standoffs; installed on south-facing roof, 30-degree tilt

Balance of System

Inverter: Sunny Boy 1100U, 400 VDC maximum input, 145–400 VDC peak power tracking range, 240 VAC output

System performance metering: Sunny Boy LCD display



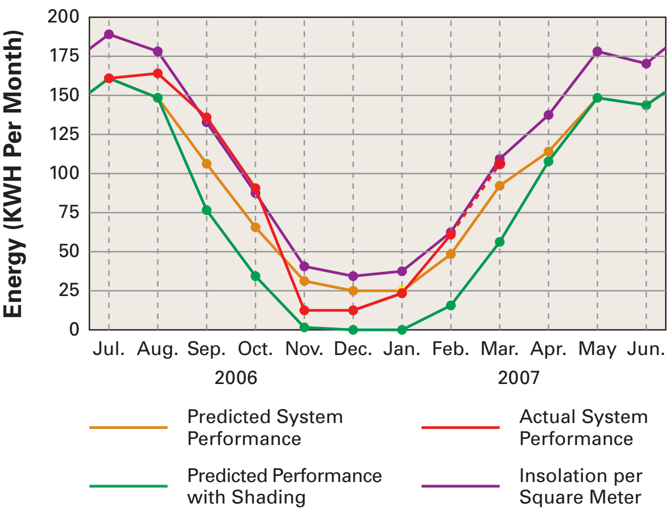
VREC member and certified electrician Darren Anderson works with Doug to finalize the grid-tie inverter wiring.

happening with net metering. Much to our astonishment, a proposal had been presented—and approved—by the utilities commission. In a hurry, that put our PV plans back on track.

Our initial system-sizing goal was to meet 100 percent of our electricity needs. I didn't think this was possible until I started researching the physical size of the system and its cost. The criteria was what we could afford and the available south-facing roof space on the house.

We'd been saving for this project for almost three years, and had initially set aside Cdn$10,000 for the project. Even when the total costs came in at about Cdn$15,000, we decided it was still something we wanted to do. I was pleasantly surprised to find that we could afford a 1 KW system that theoretically could produce all the electricity we would typically consume in a year, with the 3.7 average daily peak sun-hours we get here in Vancouver.

PV System Performance



I designed the system based on information from *Home Power* articles, selected components available from a local PV dealer, and then contacted the utility to sign the interconnection agreement. They were surprised at what we wanted to do—no other private residence had applied for their net billing program, and inexpensive utility electricity (Cdn$0.06 per KWH) made for a lengthy "payback" on a PV investment. They were only expecting small microhydro-electricity systems to become IPPs (independent power producers). But after reviewing the system schematic, they gave me the go-ahead.

Although I felt confident that I could accomplish the installation myself, I decided to enlist the services of the Vancouver Renewable Energy Coop (VERC), a local nonprofit organization that helps install affordable renewable energy systems. They provide solar shading assessments to determine any potential shortcomings at the site, and arrange the ordering and shipping of the system components. VERC also provides a certified electrician who completes all the electrical work on their projects, helping smooth the way for an electrical inspector's approval.

Overcoming Obstacles

The existing shingles on the roof were quite old, so I reshingled the roof in preparation for the PV mounts. Although the house is old and prior renovations seemed like they were done without much forethought, I breathed a sigh of relief when the roof framing appeared to be solid, reasonably straight, and had a predictable 24-inches-on-center layout.

The wiring in the house had been touched by many hands and needed to be replaced. I pulled new wire for most of the electrical runs, and upgraded and installed a few more circuits. The old breaker panel had only 16 circuits and a separate 60-amp breaker box, so the electrician and I replaced it with a larger, 24-circuit box. He felt the inspector would not approve of maxing out the small existing panel and that it would make the PV system's AC connections very difficult.

On a sunny summer day, three VREC staff members and a handful of volunteers showed up to assist with the installation. A few hands made fast work of installing the roof mounts. Robert Baxter and Chris Bouris from VREC, along with one of the volunteers, unpacked the PV modules. While the PV modules were being installed, VERC staff electrician Darren Anderson and I replaced the old main breaker panel.

The installation was completed in about two days. Once all the electrical connections were tested, the system was brought online on a beautiful sunny afternoon. When the inverter kicked on, the analog utility meter ground to a halt and then started turning backwards at a fairly fast pace. The electrical inspector came a few days later to inspect the installation with the VERC electrician, and the system passed with flying colors.

Satisfying Savings

The PV system, installed in June 2006, has worked without a hitch. I have been keeping track of its electrical production and our consumption, and estimates to date indicate that we should be able to achieve the goal of our home being

System Costs

Item	Equiv. Cost (US$)*	Cost (Cdn$)
6 Sharp NT-175U1 PV modules, 175 W	$7,030	$8,100
Sunny Boy 1100U inverter	2,118	2,440
Labor	868	1,000
Goods & services tax	792	912
Provincial sales tax	792	912
Electrical hardware	781	900
Permits & licensing	641	739
Custom PV roof mounts & hardware	590	680
Shipping	226	260
Total	$13,838	$15,943
Less Sales Tax Rebate	-792	-$912
Grand Total	$13,046	$15,031

*Based on a conversion rate of US$0.87 = Cdn$1

a net-zero electrical user. With its annual net metering program, the utility will credit us for excess energy the system feeds into the grid—at the same price per KWH that we pay for utility electricity. We still pay a small monthly fee—Cdn$6—just to be connected to the grid, but are billed biannually.

For us, the PV system was icing on the cake. At present prices for electricity, we couldn't justify the system solely on its economic payback, but it offers some indirect benefits. Besides insulating us from future electricity rate hikes, preparing for the system with efficiency projects reduced our energy consumption, whittling down our utility bills. Second, by using solar energy for our electricity, we're decreasing our ecological footprint and greenhouse gas emissions. We also wanted to show people in our community that using solar energy is feasible, even in our notoriously rainy climate.

But perhaps most importantly, we wanted to point out that you don't have to generate electricity by "alternative" means to have a positive environmental impact—you can do a world of good just by reducing your needs.

Access

Doug Horn, 418 East 11th St., N. Vancouver, BC, Canada V7L 2H2 • 604-980-8645 • dug_horn@shaw.ca

Vancouver Renewable Energy Coop • 778-869-8333 • www.vanrenewable.org

System Components:
Sharp Electronics Corp. • 800-765-2706 or 714-903-4600 • www.solar.sharpusa.com • PV modules

SMA America Inc. • 530-273-4895 • www.sma-america.com • Inverter

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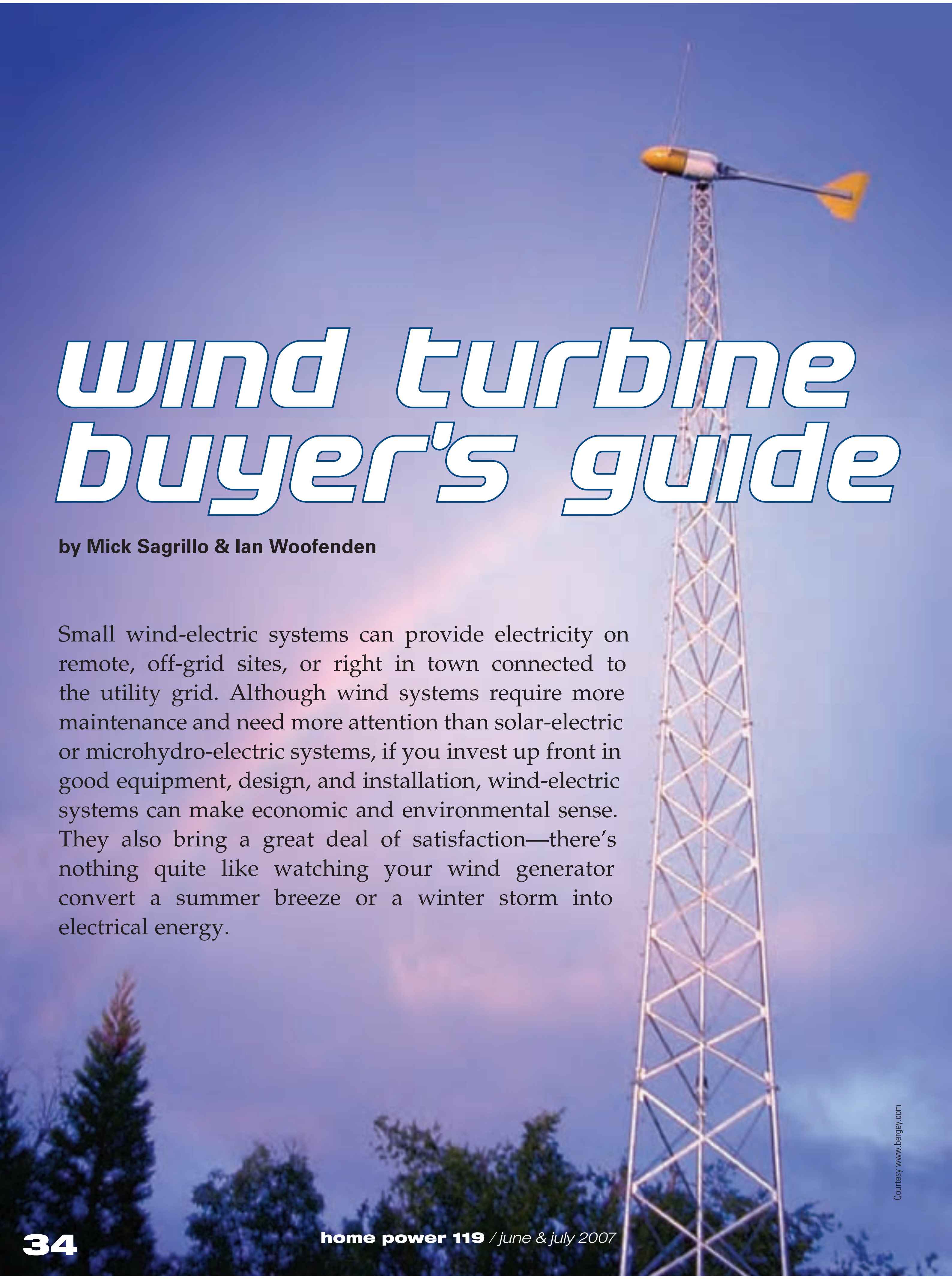
Formerly Global Resource Options

wind turbine buyer's guide

by Mick Sagrillo & Ian Woofenden

Small wind-electric systems can provide electricity on remote, off-grid sites, or right in town connected to the utility grid. Although wind systems require more maintenance and need more attention than solar-electric or microhydro-electric systems, if you invest up front in good equipment, design, and installation, wind-electric systems can make economic and environmental sense. They also bring a great deal of satisfaction—there's nothing quite like watching your wind generator convert a summer breeze or a winter storm into electrical energy.



Courtesy www.bergey.com

"Small wind," in our definition, starts with turbines with rotors (turbine blades and hub) that are about 8 feet in diameter (50 square feet of swept area). These turbines may peak at about 1,000 watts (1 kilowatt; KW), and generate about 75 kilowatt-hours (KWH) per month with a 10 mph average wind speed. Turbines smaller than this may be appropriate for sailboats, cabins, or other applications that require only a small amount of electricity. But if you want a significant amount of energy, you need a rotor with significant swept area—it is, after all, the wind turbine's "collector."

On the other end of the "small wind" scale, it's reasonable to include turbines with rotors up to 56 feet in diameter (2,500 square feet of swept area). These turbines may peak at about 90,000 watts (90 KW), and generate 3,000 to 5,000 KWH per month at a 10 mph average wind speed. Turbines of this scale are appropriate for very large homes, farms, small businesses, schools, or institutions that use a lot of electricity, or for heating applications, village power, and other major energy uses.

In between 8 feet and 56 feet are various sizes of turbines that can accommodate a variety of energy appetites. It's crucial that you have an accurate idea of what your energy usage is and the wind resource available at your site, so you can match the turbine's output to your energy needs.

Sizing a wind-electric system is quite different than sizing a solar-electric (PV) system. With a PV system, space permitting, you can add capacity either as your needs grow, or as you can afford it. With a wind-electric system, this is simply not the case. A wind turbine is not incremental. Nor do people typically add more wind turbines and towers as money becomes available. Because wind is more cost effective as you increase in system size, most people put up only one wind turbine, with the intent of offsetting a large percentage of their electric bill or, in off-grid systems, meeting most or all of their electrical energy requirements.

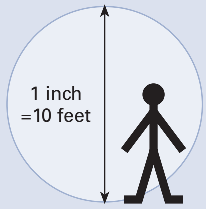
System Components

The wind generator (or "turbine") is only one component in a wind-electric system, and very often is not even the most expensive component. You need *all* of the necessary components to have a functional system. Plan ahead to buy quality components properly matched to each other and to your energy use. A complete wind-electric system includes:

- Turbine—generates electricity using the wind's energy
- Tower—supports the turbine, getting it up out of the turbulent zone created by trees and buildings, and exposes the turbine to much more "fuel"
- Wiring and conduit—carries the electricity down the tower and to power-conditioning equipment
- Controller/Electronics—controls charging of battery or input to inverter
- Batteries—used for storage in off-grid systems or grid-tied systems with battery backup
- Inverter—converts direct current (DC) electricity from batteries or rectifier to alternating current (AC) for home use or "storage" on the utility grid
- Metering—allows user to understand and manage system operation

Swept Area

The diameter of a wind turbine's rotor defines its swept area, the most important variable in the final energy generated. In the wind turbine specifications on the following pages, the blue circles represent the relative swept area of each turbine, drawn to scale.



Many Machines

The world is full of small wind generators. Chinese manufacturing numbers dwarf U.S. production, and European companies make dozens of models as well. This article covers home-scale wind generators, either manufactured or imported, that are supported in North America. The turbines profiled are readily available to buyers in the United States and Canada. And service, parts, and support are also available, either directly through the manufacturers, or through dedicated importers.

Other machines have been imported into North America in limited numbers, by individual owners or companies. Some of these may end up having long-term support from North American importers. Others may not. We suggest that you approach buying these machines with caution. If you're patient and willing to take a bit of risk, you may want to try one of these. You might end up with a real winner, or you may be stuck waiting for parts or a response from a distant manufacturer.

Home-scale wind generators come and go. We do not know enough about the quality of the equipment nor the responsiveness of the manufacturers listed below to make any firm recommendations. Our non-exhaustive list of other turbines we know about in North America includes:

- Aircon—a German machine with a 23-foot-diameter rotor
- Énergie PGE—from Canada, 36-foot-diameter rotor
- Iskrawind—a UK machine with an 18-foot-diameter rotor
- Tulipo—a Dutch machine with a 16-foot-diameter rotor
- Various other machines, including Aeromax Lakota, Air-O-Power, Anhua, Exmok, E-Mark, Gryphon, Trillium, and Cyclone

Other machines are under development. It's very hard to predict what will actually come to market, and how they will perform. A few look promising to us. One is a new induction generator design from Earth Turbines, a new company founded by David Blittersdorf of NRG Systems, which has long experience in wind monitoring. Another is the Endurance, developed by an engineering team in Utah, and also using an induction design. Apply standard cautions if considering these or any other new turbine—there's nothing like a real-world track record!

Abundant Renewable Energy

Manufacturer: 503-538-8298 • www.abundantre.com

ARE 110

Rotor diameter: 11.8 feet (3.6 m)
Swept area: 110 square feet (10.2 m^2)
Rated rpm: 340
Predicted energy output at average wind speeds: 135 KWH per month at 8 mph; 262 at 10 mph; 420 at 12 mph
Application: Batteryless grid-tie or 48 VDC battery charging
Price (MSRP): $11,500 for ARE 110 wind turbine, SMA Windy Boy inverter, voltage clamp, and resistor load; $8,870 for 48 VDC turbine, charge controller, and diversion load
Warranty: 5 years

ARE 442

Rotor diameter: 23.6 feet (7.2 m)
Swept area: 442 square feet (41 m^2)
Rated rpm: 140
Predicted energy output at average wind speeds: 623 KWH per month at 8 mph; 1,171 at 10 mph; 1,831 at 12 mph
Application: Batteryless grid-tie; battery charging system under development
Price (MSRP): $36,000 for turbine, two SMA Windy Boy 6000U inverters, voltage clamp, and resistor loads
Warranty: 5 years

Bergey Windpower

Manufacturer: 405-364-4212 • www.bergey.com

Bergey XL.1

Rotor diameter: 8.2 feet (2.5 m)
Swept area: 53 square feet (4.9 m^2)
Rated rpm: 450
Predicted energy output at average wind speeds: 55 KWH per month at 8 mph; 115 at 10 mph; 188 at 12 mph
Application: 24 VDC battery charging
Price (MSRP): $2,590 without controller or inverter
Warranty: 5 years

Bergey Excel

Rotor diameter: 23 feet (7 m)
Swept area: 415 square feet (38.6 m^2)
Rated rpm: 300
Predicted energy output at average wind speeds (battery charging/batteryless grid-tie): 240/340 KWH per month at 8 mph; 520/680 at 10 mph; 900/1,090 at 12 mph
Application: Batteryless grid-tie; 48, 120, 240 VDC battery charging
Price (MSRP): $22,900 for BWC XL-R, 48 VDC; $21,900 for BWC XL-R, 120 or 240 VDC; $27,900 for BWC XL-S, 240 VAC with inverter
Warranty: 5 years

Wind Turbine Basics

Boiled down to its simplest principles, a wind generator's rotating blades convert the wind's kinetic energy into rotational momentum in a shaft. The rotating shaft turns an alternator, which makes electricity. This electricity is transmitted through wiring down the tower to its end use.

The **blades** use engineered airfoils, matched to the alternator, that capture the wind's energy. Most modern wind generators use three blades, the best compromise between the highest efficiency possible (one blade) and the balance that comes with multiple blades. Together, the blades and the hub they are attached to are termed the "rotor," which is the "collector" of the system, intercepting winds that pass by. Most turbines on the market today are upwind machines—their blades are on the windward side of the tower. A few downwind machines are available, but neither configuration has a clear performance advantage over the other.

In most small-scale designs, the rotor is connected directly to the shaft of a permanent magnet **alternator**, which creates wild, three-phase AC. Wild, three-phase electricity means that the voltage and frequency vary continuously with the wind speed. They are not "fixed" like the 60 Hz, 120 VAC electricity coming out of common household outlets. The wild output is rectified to DC to either charge batteries or feed a grid-synchronous inverter. In most designs up to 15 KW in peak capacity, the rotor is usually connected directly to the alternator, which eliminates the additional maintenance of gears. In systems 20 KW and larger, as well as some smaller wind systems (like the Endurance, Tulipo, or Aircon), a gearbox is used to increase alternator speed from a slower turning rotor.

The blades must turn to face the wind, so a **yaw** bearing is needed, allowing the wind turbine to track the winds as they shift direction. The **tail** directs the rotor into the wind. Some sort of **governing system** limits the rotor rpm as well as generator output to protect the turbine from high winds. A **shutdown mechanism** is also useful to stop the machine when necessary, as during an extreme storm, when you do not need the energy, or when you want to service the system.

Eoltec Wind Turbines

Importers:
Pine Ridge Products LLC • 406-738-4283 • www.pineridgeproducts.com

Solacity • 613-686-4618 • www.solacity.com

Eoltec 6 KW

Rotor diameter: 18.4 feet (5.6 m)
Swept area: 265 square feet (24.6 m^2)
Rated rpm: 245
Predicted energy output at average wind speeds: 294 KWH per month at 8 mph; 558 at 10 mph; 892 at 12 mph
Application: Batteryless grid-tie
Price (MSRP): $25,200 with inverter
Warranty: 5 years

Kestrel Wind Turbines

Importer: DC Power Systems • 800-967-6917 • www.dcpower-systems.com

Kestrel 800

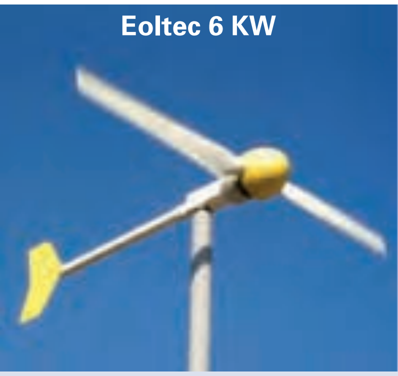
Rotor diameter: 7 feet (2.1 m)
Swept area: 38.5 square feet (3.6 m^2)
Rated rpm: 1,000
Predicted energy output at average wind speeds: 40 KWH per month at 8 mph; 80 at 10 mph; 125 at 12 mph
Application: Batteryless grid-tie or 12, 24, 48 VDC battery charging
Price (MSRP): $1,995 without controller or inverter
Warranty: 5 years

Kestrel 1000

Rotor diameter: 10 feet (3 m)
Swept area: 79 square feet (7.3 m^2)
Rated rpm: 650
Predicted energy output at average wind speeds: 75 KWH per month at 8 mph; 130 at 10 mph; 210 at 12 mph
Application: 12, 24, 48 VDC battery charging
Price (MSRP): $2,950 without controller or inverter
Warranty: 5 years

Kestrel 3000

Rotor diameter: 12.5 feet (3.8 m)
Swept area: 120 square feet (11.2 m^2)
Rated rpm: 500
Predicted energy output at average wind speeds: 130 KWH per month at 8 mph; 230 at 10 mph; 375 at 12 mph
Application: Batteryless grid-tie or 48 VDC battery charging
Price (MSRP): $8,400 with controller and dump load, without inverter
Warranty: 5 years



Understanding the Ratings

Wind turbine rating is a tricky affair. While solar-electric module or microhydro-electric turbine production can be predicted fairly realistically based on rated output, this number is very misleading with wind turbines. Why? Because rated output is pegged to a particular wind speed, and different manufacturers use different wind speeds to determine rated output. Also, the power available in the wind varies with the *cube* of its speed, so small increases in wind speed result in large increases in power available to the rotor. A 10 percent increase in wind speed yields a 33 percent increase in power available in the wind. Conversely, this means that a turbine rated at 1,000 watts at 28 mph might produce only 125 watts or less at half that wind speed, 14 mph.

So what's a wind turbine buyer to do? *Ignore* the peak output and the power curve. Look for the monthly or annual energy numbers for the turbine, estimated for the average wind speed you expect or measure at your site. These will be given in KWH per month (or year) in the manufacturer's specifications for each turbine. Energy is what you're after, not peak power! If, for example, you are looking for a turbine that can produce 300 KWH per month, and you know that you have a 10 mph average wind speed at the proposed turbine height, you can shop for a turbine that is predicted to generate that much energy in that average wind speed.

If you can't get energy production estimates from the manufacturer or a turbine owner, look for a different manufacturer. This is basic information that any manufacturer should supply. However, knowing a turbine's swept area may also help you calculate the annual energy output for the wind turbine. All other things being equal, "there's no replacement for displacement." Hugh Piggott gives a rough formula for calculating output based on average wind speed and swept area in his *HP102* article (see Access). Jim Green at the National Renewable Energy Lab (NREL) developed a similar formula: annual energy output (AEO) in KWH = 0.01328 x rotor diameter (ft.) squared x average wind speed (mph) cubed.

Proven Energy

Importers:
Lake Michigan Wind & Sun • 920-743-0456 • www.windandsun.com

Solar Wind Works • 877-682-4503 • www.solarwindworks.com

Proven WT 0.6

Rotor diameter: 8.4 feet (2.6 m)
Swept area: 55 square feet (5.1 m^2)
Rated rpm: 500
Predicted energy output at average wind speeds: 42 KWH per month at 8 mph; 83 at 10 mph; 124 at 12 mph
Application: Batteryless grid-tie; 12, 24, 48 VDC battery charging
Price (MSRP): $4,870 without controller or inverter
Warranty: 2 years; extended warranty available

Proven WT 2.5

Rotor diameter: 11.1 feet (3.4 m)
Swept area: 97 square feet (9 m^2)
Rated rpm: 300
Predicted energy output at average wind speeds: 167 KWH per month at 8 mph; 293 at 10 mph; 417 at 12 mph
Application: Batteryless grid-tie; 24, 48 VDC battery charging
Price (MSRP): $9,650 without controller or inverter
Warranty: 2 years; extended warranty available

Proven WT 6

Rotor diameter: 18 feet (5.5 m)
Swept area: 254 square feet (23.6 m^2)
Rated rpm: 200
Predicted energy output at average wind speeds: 417 KWH per month at 8 mph; 667 at 10 mph; 1,083 at 12 mph
Application: Batteryless grid-tie or 48 VDC battery charging
Price (MSRP): $20,500 without controller or inverter
Warranty: 2 years; extended warranty available

Proven WT 15

Rotor diameter: 29.5 feet (9 m)
Swept area: 683 square feet (63.5 m^2)
Rated rpm: 150
Predicted energy output at average wind speeds: 777 KWH per month at 8 mph; 1,451 at 10 mph; 3,080 at 12 mph
Application: Batteryless grid-tie or 48 VDC battery charging
Price (MSRP): $39,340 without controller or inverter
Warranty: 2 years; extended warranty available


Proven WT 0.6


Proven WT 2.5


Proven WT 6


Proven WT 15

Other Considerations

A turbine's revolutions per minute (rpm) at its rated wind speed can give you some idea of the relative aerodynamic sound of the machine, and also speaks to longevity. Slower-turning wind turbines tend to be quieter and last longer. High rpm machines wear out components, such as bearings, much faster. In addition, the faster blades move through the air, the greater the possibility that they will waste some of that energy as sound from the blades.

Some manufacturers make only battery-charging machines, and may offer a variety of turbine voltages. Others produce machines intended to connect to grid-synchronous inverters without batteries. One machine even includes an inverter integrated with the turbine itself. Make sure you're buying a machine that is appropriate for your intended use.

Make Your Choice

Trying to keep an inexpensive wind generator running can be an uphill battle that you'll soon tire of. But expect to pay more for a better machine—it's a tough job to design and manufacture a long-lasting, small-scale wind generator.

The bottom line: Buy a turbine that has a very good track record and a good warranty—five years is preferable but not always available in the small wind industry. A warranty is one indication of the manufacturer's confidence in their product, and their intention to stand behind it.

Real-world reports from users carry even more weight than a warranty, so search for people who own the model of turbine you're considering buying, and get the straight scoop from them about performance, durability, reliability, and maintenance issues.

Note that a number of the wind turbines listed here are relatively new introductions with not very much customer run-time in North America. These turbines include the ARE, Eoltec, Kestrel, and Skystream. We recommend that you contact either your local wind turbine installer, or the manufacturers or importers and find out how many of these machines are actually operating in North

Southwest Windpower

Manufacturer: 928-779-9463 • www.windenergy.com

Whisper 100

Rotor diameter: 7 feet (2.1 m)
Swept area: 38.5 square feet (3.6 m^2)
Rated rpm: 1,200
Predicted energy output at average wind speeds: 30 KWH per month at 8 mph; 65 at 10 mph; 100 at 12 mph
Application: 12, 24, 36, 48 VDC battery charging
Price (MSRP): $2,475 with controller
Warranty: 5 years

Whisper 200

Rotor diameter: 9 feet (2.7 m)
Swept area: 63.5 square feet (5.9 m^2)
Rated rpm: 1,100
Predicted energy output at average wind speeds: 60 KWH per month at 8 mph; 125 at 10 mph; 190 at 12 mph
Application: 12, 24, 36, 48 VDC battery charging
Price (MSRP): $2,995 with controller
Warranty: 5 years

Skystream 3.7

Rotor diameter: 12 feet (3.6 m)
Swept area: 113 square feet (10.5 m^2)
Rated rpm: 325
Predicted energy output at average wind speeds: 100 KWH per month at 8 mph; 240 at 10 mph; 380 at 12 mph
Application: Batteryless grid-tie, or battery charging through battery-based inverter (not included) AC input
Price (MSRP): $5,400, including turbine-integrated batteryless inverter
Warranty: 5 years

Whisper 500

Rotor diameter: 15 feet (4.6 m)
Swept area: 176 square feet (16.4 m^2)
Rated rpm: 800
Predicted energy output at average wind speeds: 170 KWH per month at 8 mph; 330 at 10 mph; 538 at 12 mph
Application: Batteryless grid-tie; 24, 32, 48 VDC battery charging
Price (MSRP): $7,675 for battery charging with controller; $12,125 for grid tied with inverter
Warranty: 5 years


Whisper 100


Whisper 200


Skystream 3.7


Whisper 500

America. Then contact the owners, and inquire about their experience and satisfaction with both the machine and the manufacturer or importer.

When you look at prices, keep in mind that just buying a wind turbine will not get you any wind-generated electricity. You'll also need most or all of the components mentioned earlier. Also budget for equipment rental, like a backhoe and crane, concrete and rebar, electrical components, shipping, and sales tax. Unless you do all of the work yourself, also factor in installation labor expenses. These costs can add up significantly, so make sure that you research and understand all of the associated expenses before committing to a purchase. Many people are quite surprised to learn that the wind turbine cost can range from only 10 percent to as much as 40 percent of the entire wind system's expenses.

Small-scale wind energy is not for the half-hearted, uninvolved, or uncommitted, and probably not for folks who never change the oil in their vehicles (or are willing to spend the bucks to hire someone to do the tower work). The North American landscape is littered with failed installations: Designs not fully thought-out or tested, machines bought because they were cheap, and installations that required more time and money for repairs than they ever yielded in electricity generated. Many of the failures were the result of wishful thinking and too little research. That said, there are tens of thousands of happy wind-electric system owners. These owners did their homework—purchasing, designing, and installing rugged and well-thought-out systems on adequately sized towers. In addition, they are either committed to maintaining the systems, or to hiring someone to do this regular work.

While many first-time wind turbine buyers may be looking for a bargain, second-time wind turbine buyers are seeking the most rugged machine they can afford. You can avoid a painful "learning experience" by focusing on durability, production, warranty, and track record, and *not* on price alone, or on peak output. You don't want to depend on the low bidder for something as important to you as your long-term energy investment.

Vestas

Rebuilders:
Energy Maintenance Service LLC • 605-272-5398 • www.energyms.com

Halus Power Systems • 510-780-0591 • www.halus.com

Vestas V-15

Rotor diameter: 50 feet (15 m)
Swept area: 1,964 square feet (182 m^2)
Rated rpm: 53
Predicted energy output at average wind speeds: N/A at 8 mph; 3,354 KWH per month at 10 mph; 5,371 at 12 mph
Application: Batteryless grid-tie
Price (MSRP): $140,000 installed on 110-foot tower
Warranty: 1 year; extended warranties available

Vestas V-17

Rotor diameter: 56 feet (17 m)
Swept area: 2,462 square feet (229 m^2)
Rated rpm: 45–50
Predicted energy output at average wind speeds: N/A at 8 mph; 5,060 KWH per month at 10 mph; 8,198 at 12 mph
Application: Batteryless grid-tie
Price (MSRP): $180,000 installed on 132-foot tower
Warranty: 1 year; extended warranty available

Wind Turbine Industries

Manufacturer: 952-447-6064 • www.windturbine.net

WTIC 31-20

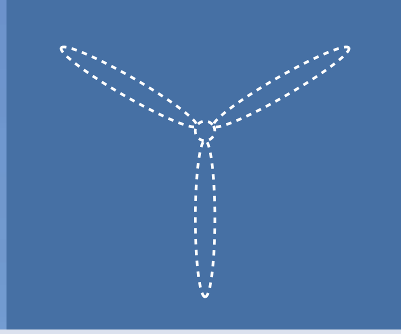
Rotor diameter: 31 feet (9.5 m)
Swept area: 754 square feet (70 m^2)
Rated rpm: 175
Predicted energy output at average wind speeds: 819 KWH per month at 8 mph; 1,644 at 10 mph; 2,691 at 12 mph
Application: Batteryless grid-tie
Price (MSRP): $33,900 with inverter
Warranty: 1 year; extended warranty available

Vestas V-15

Vestas V-17

WTIC 31-20

Your Wind Turbine?



In our next article, we'll discuss system design and the turbine selection process in more detail. Meanwhile, we encourage you to start with an energy analysis of your home—find out how many kilowatt-hours you need and how you can reasonably pare that number down! Next, find out what your wind resource is—guessing on this will make your whole system design a guess. And when it's time to buy, choose a rugged turbine that will produce what you expect it to, and do that for years to come.

Note: All numbers are provided by manufacturers or extrapolated from their data, since no comprehensive, independent testing data is available. Turbine performance may vary at your site.

Access

Mick Sagrillo, E3971 Bluebird Rd., Forestville, WI 54213 • msagrillo@wizunwired.net

Ian Woofenden, PO Box 1001, Anacortes, WA 98221 • ian.woofenden@homepower.com

"Anatomy of a Wind Turbine," Ian Woofenden & Hugh Piggott, *HP116*

"Wind Generator Tower Basics," Ian Woofenden, *HP105*

"Estimating Wind Energy," Hugh Piggott, *HP102*

Third Annual Small Wind Power Conference: A Gathering of Installers, Manufacturers, Dealers & Distributors • June 12-13, '07 • Holiday Inn Hotel & Convention Center, Stevens Point, WI • For information, contact Amy Heart at the MREA • 715-592-6595 • amy@the-mrea.org

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The Half Plan

by Gary Reysa

Reducing Your Carbon Footprint Part Two: Trim Your Waste Line

Whittle down your utility bills—and spare your pocketbook and the planet—with these quick and easy energy and greenhouse-gas saving projects.

Last year, my family took on the challenge of cutting our energy consumption—and related carbon dioxide (CO_2) emissions—by 50 percent. We identified more than twenty projects that fit our skill levels and particular household needs, and started implementing them one project at a time. (For tips on prioritizing your own CO_2 reduction plan, see the sidebar, opposite page.)

Slimming down our energy use saves us hundreds of dollars on our electricity and water heating bills each year, while reducing our carbon footprint—the total amount of CO_2 our household generates. The six simple projects detailed here save an estimated 5 tons of CO_2 pollution annually. And as electricity rates continue to rise, we'll enjoy even greater financial savings in years to come.

Taming the PCs

Although their individual energy use might not seem significant, added together, the electricity consumption of home office equipment—personal computers and their peripherals, like printers, routers, and scanners—can add up in a hurry.

Quick measurements of each appliance's energy consumption with a watt-hour meter (see Access) showed me that my two PCs, two printers, a scanner, and a router and communications gear, drew 297 watts under steady-state conditions. Left on day and night, these seemingly innocuous, "small" electronics would consume a whopping 7.1 kilowatt-hours (KWH) per day, 213 KWH per month, or 2,592 KWH per year! My first step was to configure the PCs to go to "sleep"

after 15 minutes of inactivity. With the computers in this mode approximately 8 hours every day and the other peripherals on, this reduced the load to 59 watts, saving 695 KWH per year.

Next, I put all these energy-suckers on a plug strip so, with a flip of a switch, I could shut off everything completely when the hardware is not in use—about 10 hours overnight. This painless fix saves almost 1,084 KWH a year—and puts an extra $100 (or more, as electricity rates rise) in my pocket.

Project 1: Power Down & Plug Strips

Up-front Cost: $20 (Two $10 plug strips)

DIY Labor: 1 hr. (includes trip to the store)

DIY Difficulty: 1 (on a scale of 10)

Annual Energy Savings: 1,779 KWH

First-Year Energy Cost Savings: $178

Projected 10-Year Savings: $2,834

Annual CO_2 Reduction: 3,557 lbs.

Macintosh (left) and Windows (right) energy saver settings.

Reduce Your Carbon Footprint

Taking steps to reduce your energy use can pay off—both economically and environmentally—by reducing your utility bills and cutting your household's greenhouse gas emissions. Follow these four easy steps to start saving.

1. Conduct a home energy audit and make a list of potential projects to reduce your household energy use. Many utilities will send out a technician, often for free, to assess your home's efficiency and provide a report and recommendations for efficiency upgrades. If you're off the grid, or your utility doesn't offer audits, you can perform an energy audit yourself, using the online Home Energy Saver program (see Access).

2. Estimate the cost, energy savings, time and degree of difficulty, and greenhouse gas reduction for each project. For this article's projects, financial savings in fuel in the first year are based on the projected kilowatt-hours (KWH) saved, and multiplied by 10 cents per KWH—my cost for utility electricity. The projected 10-year fuel savings assumes a 10 percent rise in fuel prices each year. Converting all nonelectrical forms of energy use to KWH will allow you to compare energy savings for electricity, transportation, and heating projects on the same basis.

Some handy conversion factors:

1 KWH = 3,412 Btu

1 gal. of propane = 92,000 Btu or 27 KWH

1 therm of natural gas = 100,000 Btu or 29.3 KWH

1 gal. of gasoline = 125,000 Btu or 36.6 KWH

1 gal. of heating oil = 139,000 Btu or 40.7 KWH

To estimate greenhouse gas savings for each project, I used the calculator at www.infinitepower.org/calc_carbon.htm.

3. Using the results of your evaluations, list all the projects that have good payoffs—both economic and environmental. Prioritize projects according to CO_2 savings, and budget, time, and skill constraints.

4. Keep a file of your utility bills to review, so you can see what progress you are making. The bills can also be used to demonstrate your home's improved energy efficiency, if you plan to sell it, and may be needed to claim rebates or tax credits.

Brighter Lighting

If you're still using watt-devouring incandescents, come out of your energy cave and into the light with compact fluorescent (CF) bulbs, which use about one-quarter of the electricity and last eight to ten times longer. A variety of CF bulb sizes and shapes accommodate many different types of fixtures—from wall sconces to recessed ceiling cans. And for those traditionalists who prefer a rounded bulb shape instead of twists or tubes, some CFs are cleverly disguised to resemble old-fashioned incandescent bulbs. Some brands will even work in outdoor fixtures at 20°F below zero. Although CF bulbs are more expensive than their incandescent counterparts (but prices are dropping all the time), their energy efficiency offers a quick payback on a modest investment—even if you're replacing all of the bulbs in your home, like I did.

To encourage this quick and easy energy savings, some utilities will provide customers with free CFs or rebates to help defray the initial cost of buying bulbs. Check with your electric company to see if they offer any incentives.

Carbon & King Coal

If you thought burning coal for electricity went extinct long ago, think again: Almost half of the electricity in the United States is produced from coal-fired power plants.

Besides contributing to acid rain, rising levels of mercury in the environment, and particulate pollution that can cause respiratory problems in humans, coal-fired electric power plants are responsible for 32 percent of greenhouse gas emissions in the United States.

Coal-fired electricity plants are only about 35 percent efficient, and coal is a very high-carbon-content fuel. This combination means that this electricity comes at a very high greenhouse gas cost. If you use utility power that has a high percentage of coal-fired generation, don't heat with electricity. This practice results in producing significantly more pollution compared to using other energy sources for heating. In these regions, using an electric resistance heater compared to a natural gas-fired furnace results in about four times the greenhouse gas emissions (per Btu of heat) if your utility relies on coal as its primary fuel.

The 100-plus new coal-fired plants planned across the United States represent a real threat to getting a handle on greenhouse gas emissions and climate change. This alone is one reason to address electricity consumption as part of your carbon emissions reduction plans. If demand drops enough, fewer plants will be built.

Whenever possible, look to other energy sources, like the sun. If your site or situation can't accommodate renewables, investigate utility options for supporting large-scale renewable energy (RE) projects. Many utilities now offer green energy programs. Supporting these programs lets your utility know that RE is a priority for you, and part of the small premium you'll pay generally goes to support the development of new RE projects. If your utility doesn't offer a green power option, purchase renewable energy credits (RECs) and petition your utility to develop a clean power program (see Access).

Project 2: Compact Fluorescent Lightbulbs

Up-front Cost: $50 (for 29 CF bulbs; includes $15 utility rebate)

DIY Labor: 1 hr.

DIY Difficulty: 1

Annual Energy Savings: 1,168 KWH

First-Year Energy Cost Savings: $117

Projected 10-Year Savings: $1,861

Annual CO_2 Reduction: 2,336 lbs.

CF Bulb Exchange Savings

Location	Incand. Watts	–	CF Watts	=	Savings Per Bulb (Watts)	Qty.	Hours Per Day	KWH Savings Per Year
Kitchen	65		15		50	6	4.0	438
Upstairs office	65		15		50	4	2.0	146
Downstairs office	65		15		50	2	3.0	110
Living room	100		23		77	3	3.0	253
Master bedroom	100		23		77	2	1.0	56
Master bath	40		7		33	6	1.0	72
Half bath	40		7		33	4	0.5	24
Dining room	60		13		47	2	2.0	69
							Total Energy Savings	1,168

Finding the Phantoms

Chances are, your house is "leaking" electricity. Mine was: Many of the small electronics in my home were using energy even when they were shut down and weren't providing any useful service. With my watt-hour meter, I measured all the 120-volt plug-in appliances in the house to see how many watts they were drawing when they were switched "off"—their phantom loads.

I found a total of about 80 watts being used by devices that were "off." This may not sound like a huge amount, but 80 watts, 24 hours a day, 7 days a week, translates into 700 KWH per year! I was able to either unplug appliances or use power strips (for added convenience) to eliminate 20 of the 80 watts. The other 60 watts was my fancy satellite TV receiver that used 60 watts when on and 60 watts when "off." I replaced it with the new model that uses 15 watts when it's in standby mode (we don't turn it off because it has a long boot time, and we use it to record some programs at night). I'm lobbying my Congressperson to have all electrical devices labeled with their wattage when they're turned "off"—also known as "standby loss"—to avoid future frustrations with like products.

Project 3: Defeating Phantom Loads

Up-front Cost: $70 (for two plug strips and upgraded satellite receiver)

DIY Labor: 4 hrs. (includes measuring consumption of individual appliances)

DIY Difficulty: 2

Annual Energy Savings: 569 KWH

First-Year Energy Cost Savings: $57

Projected 10-Year Savings: $907

Annual CO_2 Reduction: 1,137 lbs.

Using Plug Strips saves 1,137 lbs. CO_2 per year

New Fridge saves 1,441 lbs. CO_2 per year

Wiser Appliances

An appliance has two price tags—what you pay to take it home and what you pay for the energy (and water) it uses from that day forward. Energy Star-qualified appliances incorporate advanced designs and consume 10 to 50 percent less energy than standard models. Over time, the money you save on your utility bills can more than make up for the cost of a more expensive but more efficient model.

According to EnergyStar.gov, the refrigerator is the biggest energy-consuming appliance in most kitchens. We replaced our old refrigerator, which used about 3.2 KWH per day, with a new Energy Star model that uses about one-third that much. After much searching and debate, we settled on a conventional, 21-cubic-foot, top-freezer model that has an Energy Star rating of 448 KWH per year.

Project 4: Replacing the Fridge

Up-front Cost: $800

DIY Labor: 1 hr. (includes time to hook up water line for automatic ice maker/water dispenser)

DIY Difficulty: 2 (for hooking up water line)

Annual Energy Savings: 720 KWH

First-Year Energy Cost Savings: $72

Projected 10-Year Savings: $1,147

Annual CO_2 Reduction: 1,441 lbs.

Cleaner & Greener

We replaced our old washing machine with an horizontal-axis model. This appeared to offer some significant energy as well as water savings. But because we use cold water in the wash and rinse cycles, our energy savings was actually pretty minimal. Water heating constitutes 80 to 90 percent of a clothes washer's total energy use. You can achieve a huge savings in water heating energy (and costs) by just using cold water to wash clothes. Going from a hot wash and hot rinse to a cold wash and cold rinse on an old vertical-axis washing machine can save as much as 7 KWH per load! For a family that does seven loads of laundry per week, this could add up to 2,548 KWH a year and 5,097 pounds of CO_2—without replacing the washer.

However, our new washer does reduce the energy required for clothes drying by extracting more water from the clothes with a higher speed spin, and it reduces water use by about 7,000 gallons per year. In general, Energy Star-rated washers use one-half to one-third the water consumed by a standard washer.

Project 5: Energy-Efficient Washer

Up-front Cost: $400

DIY Labor: 0.5 hrs. (hooking up water hoses)

DIY Difficulty: 1

Annual Energy Savings: 350 KWH

First-Year Energy Cost Savings: $35

Projected 10-Year Savings: $558

Annual CO_2 Reduction: 700 lbs.

Power Up, Power Down

This project was a behavioral exercise that cost nothing to implement—and saved money and energy instantly. It was the simple exercise of retraining ourselves to turn off lights and small appliances, like our TV and stereo, when we've finished using them. We identified the equivalent of 100 watts that were on for about 12 hours per day, but I suspect it can be much more than this in many cases.

Off-grid and on-grid renewable energy users will attest to how much these behaviors can save. To break some of our old habits, we worked hard for several days on making sure that we turned off lights when we left an area—after a while, it became automatic. Good conservation habits paired with energy efficiency upgrades allow you to pare down the size of your planned renewable energy system, shaving off hundreds—and even thousands—of dollars on equipment costs. But you don't need an RE system to save. Conservation strategies pay off immediately and mean more money in the bank to spend on something other than the electricity bill.

Project 6: Change Your Ways

Up-front Cost: $0

DIY Labor: 0 hrs.

DIY Difficulty: 0

Annual Energy Savings: 438 KWH

First-Year Energy Cost Savings: $44

Projected 10-Year Savings: $698

Annual CO_2 Reduction: 876 lbs.

Turning Off Lights saves 876 lbs. CO_2 per year

Next Issue: Defeating Drafts & Improving Insulation

An inadequately insulated and sealed home is especially vulnerable to scorching summer heat and frigid winter temperatures—and high cooling and heating bills. Gary's family shares their tips on insulation and air-sealing projects that cut costs, decrease CO_2 emissions, and make a home more comfortable.

Your Solutions

What smart steps have you taken to reduce your carbon footprint? E-mail us at footprint@homepower.com. If we choose to print your projects, you'll get a free *Best of Home Power* *CD-ROM* and a one-year gift subscription to send to a friend.

Access

Gary Reysa, Build It Solar Projects • www.builditsolar.com

Carbon Calculators:
Infinite Power • www.infinitepower.org/calc_carbon.htm

Safe Climate • www.safeclimate.net

Renewable Energy Credits & Green Energy Programs:
www.eere.energy.gov/greenpower/buying/

Online Energy Efficiency Tips:
American Council for an Energy Efficient Economy • www.aceee.org

Energy Star • www.energystar.gov • Energy efficient appliances, lighting, windows, and much more

Project Evaluation Software:
Home Energy Saver • http://hes.lbl.gov/ • Online DIY home energy audit

Watt & Watt-Hour Meters:
Brand Electronics • 888-433-6600 • www.brandelectronics.com • Brand meter

Electronic Educational Devices • 877-928-8701 • www.doubleed.com • Watts Up? Meter

P3 International Corp. • 888-895-6282 • www.p3international.com • Kill A Watt meter

Reading References:
"Starting Smart: Calculating Your Energy Appetite," Scott Russell, HP102

"The Half Plan—Reducing Your Carbon Footprint; Part One: Thermal Gains," Gary Reysa, HP118

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BATTERY BOX basics

by John Meyer & Joe Schwartz

If you're planning to install an off-grid renewable energy (RE) system, or a grid-tied system designed to provide backup power during utility outages, batteries will be a necessary component. Well-planned battery enclosure design and construction will protect you, your family, and your property from potential battery mishaps, and can enhance the effectiveness of the battery bank as well.

Batteries store electrical energy using a chemical reaction, and can present chemical burn, electrocution, or explosion hazards if they are improperly handled or contained. When it comes to housing your batteries, your goal should be to provide a clean, dry, ventilated, semiconditioned space that limits unqualified people from coming into contact with the battery bank.

Safe Containment

There are three common options for safely containing your battery bank—manufactured battery enclosures, site-built boxes, and modifying off-the shelf plastic tubs or toolboxes. In addition, some very large systems use a separate, lockable, and well-vented room or shed to contain the entire battery bank and limit access.

Several RE equipment manufacturers build and sell battery enclosures fabricated from sheet metal, which are typically shipped flat for on-site assembly. Many of these enclosures are intended primarily for use with sealed battery types, such as absorbed glass mat (AGM) batteries commonly used in grid-tied RE systems. These units may not include trays to capture leaked or spilled electrolyte, or have sufficient working clearances to access flooded batteries for regular watering. As such, some manufactured enclosures are inappropriate for use with the flooded lead-acid batteries often used in off-grid systems. The individual batteries and complete battery banks used in utility backup applications are typically smaller than those used in off-grid systems, where the batteries are cycled daily and more storage is usually required for cloudy or windless periods. As a result, many of the manufactured enclosures are not designed to contain the larger batteries used in off-grid systems. If the batteries you're using are compatible with a given manufactured enclosure, the total battery pack capacity may still require purchasing multiple units. Before

A well-constructed, site-built battery enclosure.

Courtesy www.positiveenergysolar.com

you buy, make sure to consider what type of batteries you'll be using, and if the manufactured enclosure is suitable for your application.

While manufactured enclosures are the norm when it comes to battery-based grid-tie systems, site-designed and built battery boxes are the common approach for battery containment in residential-scale off-grid systems. Most of these enclosures are constructed of wood, and the designs are tailored to both the size of the battery bank and its location. Plastic tubs or toolboxes are also commonly used in off-grid systems, either by themselves or in conjunction with a wooden outer enclosure for additional physical protection.

Construction Considerations

If you're planning to build your own battery box, consider several design details.

Size. How many batteries are there, what are their physical dimensions, and what is the layout of the battery bank? These factors will determine the size of the enclosure. Draw the layout of your battery bank to scale before you start building. Allow for approximately 1/2 inch of space between each battery to facilitate air circulation around the battery bank, which will keep the individual batteries operating at similar temperatures, as well as leave some room for the slight expansion batteries may experience at elevated temperatures and as they age. Include an additional 2 to 4 inches of space around the perimeter of the battery bank, and at least 6 inches above the tops of the batteries, which will leave adequate room for interconnect cabling. If you think you may expand your battery bank in the future, size the enclosure with this in mind.

Materials. The majority of site-built battery boxes are constructed with standard framing lumber and plywood. Wood is a good material choice because it is non-conductive, and will prevent an electrical short from occurring between an exposed battery terminal or cable and the box. One shortcoming of using lumber is that over time, leaked or spilled battery electrolyte will undermine its structural integrity. A seamless (or sealed), acid-resistant liner should be placed along the bottom and sides of the box to contain battery acid spills or electrolyte overflow, and protect the wood against deterioration. Construction plastics, like polyethylene, are commonly used, and acid-resistant epoxy sealers are another good option. The height of this liner should be sufficient to hold at least 1.5 gallons (or one battery's worth) of electrolyte in case of catastrophic failure.

Structure. Battery enclosures should be structurally stout. If you don't have any framing experience, enlist the help of

Courtesy William Miller

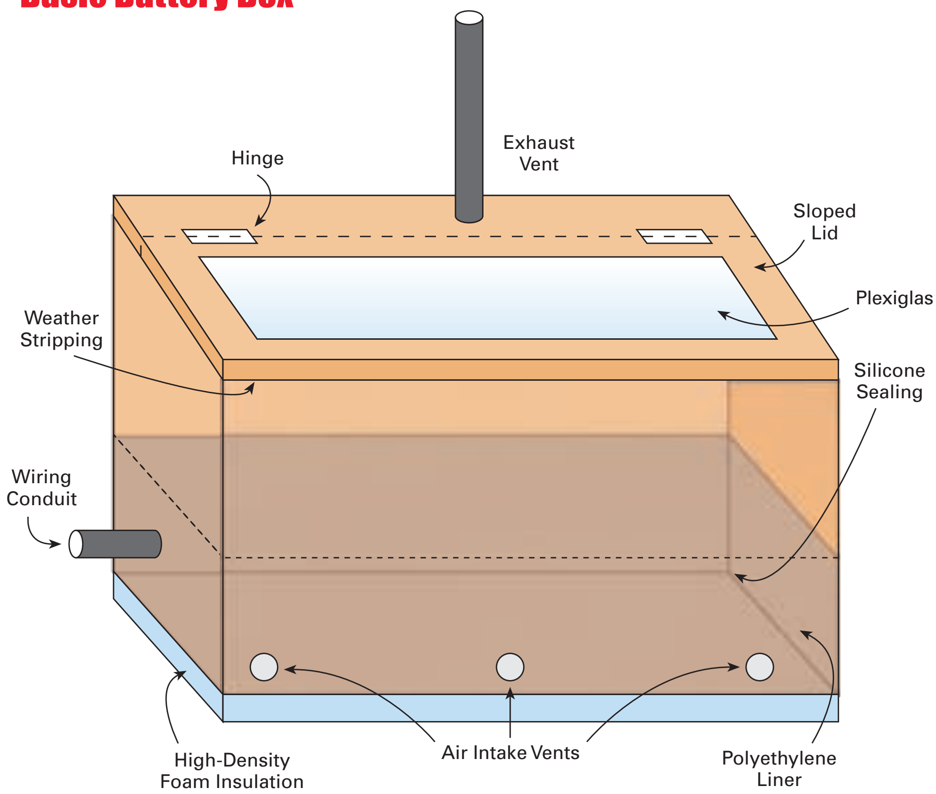
An accident waiting to happen—exposed battery terminals and lots of metal objects in the vicinity that present electrical shorting hazards. Don't try this at home!

Courtesy www.outbackpower.com

Courtesy www.midnitesolar.com

Manufactured battery enclosures are commonly used in grid-tie systems with battery backup. (Batteries not included.)

Basic Battery Box



an experienced carpenter. Compared to a freestanding battery box, a built-in battery enclosure that uses two or more existing walls requires fewer materials, is easier to construct, and provides structural integrity to the box. If you do use an existing wall surface for part of the box construction, consider replacing or covering any drywall with $^1/_2$-inch plywood or masonry/cement board.

Access. Access to the box for battery inspection and maintenance is typically from the top. Keeping this access design very basic will help ensure that critical battery service can be easily performed. A hinged lid, with a means to safely hold it open, is easier and safer than removing and replacing an unhinged, bulky box lid. Also consider making the top of your battery box sloped. This simple feature helps discourage items being placed atop the box, which can inhibit convenient access to the batteries.

Insulation. When it comes to battery enclosure design, one of the conundrums is figuring out how to keep the batteries warm in the winter and cool in the summer. At times, the

Battery Enclosures and the *National Electrical Code*

National Electrical Code (NEC) articles 480 and 690.71 address battery installation and containment, and should be referenced prior to specifying or building your battery enclosure. In most instances, residential battery systems are limited to 50 VDC nominal. (Requirements for battery packs operating at over 50 VDC nominal are not addressed here.)

Regardless of battery type (sealed or flooded), adequate ventilation is required to "prevent the accumulation of an explosive mixture." While ventilation specifics are not clearly outlined in the *NEC*, some important considerations are identified. Article 480.9 (A) states that, "hydrogen disperses rapidly and requires little air movement to prevent accumulation. Unrestricted natural air movement in the vicinity of the battery, together with normal air changes for occupied spaces or for heat removal, will normally be sufficient. If the space is confined, mechanical ventilation may be required in the vicinity of the battery."

Because hydrogen is "lighter than air and will tend to concentrate at ceiling level," the *NEC* states that "some form of ventilation should be provided at the upper portion of the structure. Ventilation can be a fan, roof ridge vent, or louvered area." A common approach used to meet these requirements, especially when flooded batteries are used, is the inclusion of one or more air intake vents installed low on the battery enclosure, used in conjunction with a pipe-connected exhaust vent that routes gases to the outdoors.

All live parts of battery systems, including terminals and cable lugs, are required to be guarded, or covered, to protect against the possibility of an electrical short if a tool or other metal object is inadvertently dropped across the batteries. In addition, access to the battery bank should be limited, either by locking the battery room or enclosure, or restricting access with some other permanent means (Article 110.27).

The battery enclosure cover or doors should allow adequate and convenient access to the battery bank for qualified people, and adequate working clearances should be provided (Article 110.26).

Finally, the *NEC Handbook* includes the following reference to flooded versus sealed battery types: "Although valve-regulated batteries are often referred to as 'sealed,' they actually emit very small quantities of hydrogen gas under normal operation, and are capable of liberating large quantities of explosive gases if overcharged. These batteries therefore require the same amount of ventilation as their vented counterparts." (Article 480.9)

goal will be to ventilate the enclosure while still keeping the batteries in the correct temperature range. While there's no silver bullet, it's always a good idea to insulate at least the bottom of the battery box if it rests on a concrete slab. High-density foam insulation is the material for the job. Covering this insulation with $^{5}/_{8}$ -inch or thicker plywood will help evenly distribute the weight of the batteries. If you live in a cold climate, insulating all surfaces of the box will help contain some of the heat generated during the battery-charging process.

Sealing. Hydrogen is the lightest element, and flooded batteries release it every time they're under charge. Trying to completely seal a battery box against hydrogen release will always be a lost cause, but proper sealing approaches will help direct the majority of the gases released during charging to the outdoors via the enclosure's exhaust vent or vents. Apply a gasket around the perimeter of the box lid to help create a good seal. Flexible, $^{1}/_{8}$-inch-thick foam weather stripping, typically sold in rolls at hardware stores, works well. Corners of wooden boxes can be caulked, or sealed with an acid-proof sealant.

Venting. Most enclosures housing flooded lead-acid batteries will be directly vented to the outdoors. A 2-inch or larger pipe exiting from the highest point in the top of the box is usually sufficient. Intake venting should be placed near the bottom of the box, opposite the pipe vent, to allow incoming fresh air to replace air leaving through the upper vent. To keep out rodents and the like, the vents should be screened.

Conduit. Wiring conduit should be sealed with silicone caulk or plumber's putty, and always enter the battery enclosure below the tops of the batteries. Hydrogen gas is light, and will head skyward as soon as it leaves the batteries. Conduit runs exiting the top of the battery box can route battery gases right into your power center, which may result in component corrosion over time, and could present an explosion hazard if there was ever a spark or catastrophic failure in the power-conditioning equipment.

Siting Your Battery Bank

Besides the type of enclosure for your batteries, another decision related to your new battery bank is where to locate it. Flooded batteries release gas when they are charging, and the gas is corrosive, and potentially explosive if exposed to spark or flame. Sealed batteries can also off-gas if overcharged. As a result, never locate batteries in living spaces. Garages, shops, or dedicated rooms or outbuildings are the most common location for battery banks.

The temperature inside your battery enclosure is another important consideration. Battery capacity is temporarily diminished at low ambient temperatures, and deeply discharged batteries housed in unconditioned enclosures in cold climates are vulnerable to freezing, which can result in cracked cases, spilled electrolyte, and destroyed batteries.

On the other end of the temperature spectrum, operating batteries at temperatures above 110°F can result in the shedding of active materials from the battery plates. The resulting sediment buildup on the bottom of the case can lead to electrical short circuits. Batteries like to live at about the same temperatures humans enjoy. For optimal battery performance and longevity, select a location and enclosure design that will keep your batteries between 50°F and 80°F, and will rarely experience temperatures above 100°F or below 40°F.

Finally, locate the battery bank as close as possible to the power conditioning equipment (inverters, charge controllers, disconnects, etc.), while maintaining sufficient working clearance to access system disconnects and components for servicing. In most battery-based systems, high current is common between the batteries and the inverter. Keeping the associated cable length to a minimum will limit voltage drop and power loss, and help keep system costs down.

John Meyer's elevated, custom-built battery enclosure is located adjacent to the system power-conditioning hardware.

Courtesy John Meyer

Additional Design Ideas

Beyond the basics of battery enclosure design and construction, these additional details can help you build the perfect battery box.

Raise it. A battery box raised off the floor will provide easier access to the batteries for maintenance, and create some convenient storage space below the enclosure for battery maintenance and safety items. Depending on the specifics of your battery box location and battery size, a platform height of 18 inches should be ideal. Raised battery box designs should not be considered unless you or a friend has some construction experience, and can determine the appropriate framing

Courtesy www.zephyrvent.com

A vent fan can improve air exchange in the battery box.

Battery Dangers

- Heavy—can cause injury and damage if dropped or lifted improperly
- Contain acid that will cause burns as well as damage materials
- Flooded types regularly off-gas potentially explosive hydrogen
- Contain large amounts of stored energy, which if released inadvertently (such as with an electrical short circuit) can shock or result in fire

specifications. At more than 100 pounds per battery, a typical battery bank is very heavy. A strong and sturdy platform, and excellent protection against acid damage to the enclosure's floor sheathing and framing must be provided for any raised battery box.

Removable front. Consider making the front of your battery box removable. The only time you should need to remove this panel is when you replace your batteries, but it is far easier and safer to slide the batteries in and out of the front of the box than to lift them over the sides.

See-through top. A see-through plastic panel (Plexiglas) in the top of the box will allow visual inspection of the batteries without lifting or removing the lid. It's also a great feature if you plan to show off your system to friends, neighbors, or anyone else interested in how RE systems work.

Power venting. The *National Electrical Code* does not require the use of active or mechanical venting unless the location of your battery bank is confined in a space that does not receive the regular air exchanges that occur when doors or windows are opened and closed. However, mechanical ventilation does offer a couple of distinct advantages over passive ventilation—increased air exchange and reduced heat loss.

In battery enclosure power-venting applications, a small DC fan is installed in the exhaust vent pipe. The fan is controlled by either an auxiliary relay (some inverters and charge controllers have this feature built in) or by a separate voltage-sensing switch. When the battery voltage reaches a user-determined setpoint, the fan is turned on, drawing gases from the box. When the batteries are not charging, the fan remains off. One commonly used vent fan includes a simple back-draft damper, which closes off the exterior vent when the batteries are not charging. The big advantage is that in cold climates, outdoor air is kept out of the battery box unless the batteries are charging, which helps keep both battery temperature and capacity up during the cold months.

Another good application for active venting is if your battery bank is located in a garage or shop that you spend some time working in. The smell of the gases released by charging batteries is anything but pleasant, and power venting can significantly increase your quality of life in the shop. Keep in mind that activities that require an open flame or could lead to sparking should *never* be done in the vicinity of your battery bank.

Automatic, single-point battery watering systems make maintaining flooded lead-acid batteries a snap.

Courtesy John Meyer

Automatic battery watering system. The main maintenance task associated with flooded batteries is checking and filling battery electrolyte level. This task can be greatly simplified by using an automatic, or single-point, watering system. In these systems, the factory battery caps are removed and replaced with valved caps that are connected to a water tubing system. Distilled water stored in a small, elevated or pressurized reservoir is sent to the individual batteries when filling.

Buy It or Build It

Batteries are an expensive RE system component, and they also have a limited operational life. The better you take care of them, the longer they'll last. Limiting the depth of battery discharge and regularly recharging the bank are the two most important things you can do to keep your batteries healthy and happy. A well-designed enclosure will help you manage battery temperature, and make watering and maintaining the bank more convenient, both of which are also critical to battery longevity.

But the most important feature of a battery enclosure is the safety it provides. Preventing people who are unacquainted with batteries from coming into contact with them is job number one. Proper venting to eliminate potential corrosion and fire hazards is a close second. So build or buy that ideal battery box, and you'll have the most trouble-prone component of your RE system wrapped up tight.

Access

John Meyer, 5426 California Ave. SW, Seattle, WA 98136 • 206-915-9771 • jrmeyer@comcast.net

Joe Schwartz, *Home Power*, PO Box 520, Ashland, OR 97520 • joe.schwartz@homepower.com • www.homepower.com

Battery Enclosure Suppliers:

DP&W Power-Fab • 800-260-3792 • www.power-fab.com

MidNite Solar • 425-374-9060 • www.midnitesolar.com

OutBack Power Systems • 360-435-6030 • www.outbackpower.com

Power Battery Co. • 973-523-8630 • www.powerbattery.com

Radiant Solar Technology • 707-485-8359 • www.radiantsolartech.com

Zomeworks • 505-242-5354 • www.zomeworks.com

Enclosure Accessories:

Zephyr Industries • 719-503-0718 • www.zephyrvent.com • Power vent

Solar Converters • 519-824-5272 • www.solarconverters.com • Voltage-controlled switch

Battery watering systems:

Battery Filling Systems • 877-522-5431 • www.batteryfillingsystems.com

JWP/Pro-Fill • 616-822-7587 • www.janwp.com

GPS monitoring station at Cape Roberts, Antarctica operates year-round with solar power and a large bank of Deka Solar Gel Batteries.

Photo Courtesy of UNAVCO

How Far Off The Grid Are You?

Antarctica is the coldest continent on the planet. 98% of it is covered in ice. With no permanent human population, only the toughest plants and animals are able to survive the cold. And the same goes for your batteries. So when a government funded agency needed to deploy a photovoltaic system for monitoring land mass movement in this harsh environment, they chose Deka Solar Batteries.

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DRYING PRODUCE WITH THE SUN

by Eben Fodor

Drying food you've harvested from your garden or picked up at the local farmers' market is fun and easy. And when you're using a solar dehydrator, the fuel is free.

A solar food dryer can become an important tool for capturing the summer's bounty and enjoying healthful produce throughout the year. We all know the anticipation of plucking the first ripe tomato from the vine—and then the reality that, in no time, you've got more tomatoes than you can give away.

Some folks turn to canning and freezing to preserve their harvest, but drying can offer distinct advantages. First, it's simple and easy—if you can slice a tomato, you can dry food. Second, dried foods tend to retain more nutrients than canned foods, and don't require the energy of a freezer. Dried food is concentrated, reducing bulk and weight to one-half to one-fifteenth that of hydrated food, requiring fewer containers and less storage space. These convenient foods are easy to pack and can last as long as frozen foods, without the risk of freezer burn. Then there's the taste—with most of the water removed, a food's flavor comes through completely.

Simple Solar Design

Sun-drying foods outdoors on a screen or tray is low tech and economical, but leaves a lot of room for improvement. Open air sun-drying generally takes a while to get the food dry, putting it at risk for rot and assault from rain, dust, rodents, and insects. Indoor electric food dryers generally work well, but can consume 100 to 1,000 watt-hours every hour they run, which roughly translates into $1 to $2 (or more) per load, depending on electricity rates. But if you have a sunny area on your patio, deck, or yard, a solar dryer, made of a few basic materials, such as glass, plywood, and screens, can produce outstanding results—without energy costs or pollution.

The same energy that grows your fruits and vegetables can also dry your harvest.

Courtesy Eben Fodor

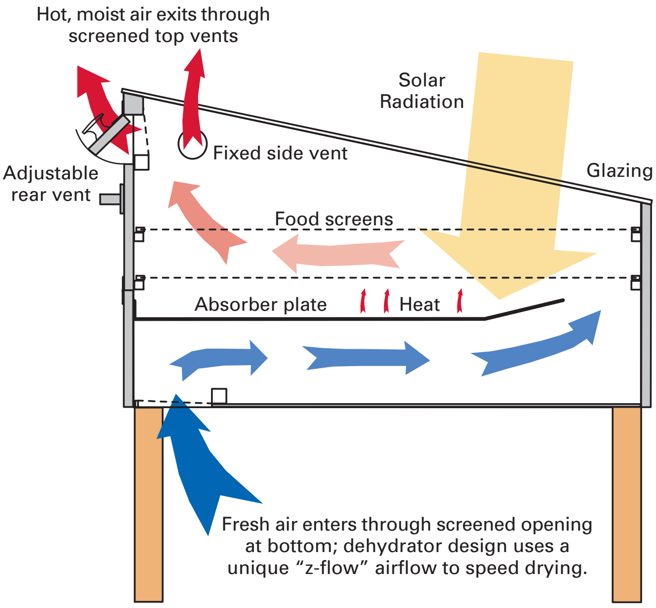
A well-designed solar dryer will work in most of the world, and anywhere in the lower 48 states where you can get two days of sunshine in a row. You can successfully dry foods in muggy climates and at outdoor temperatures down to about 50°F—as long as the sun is shining.

The basic solar dryer captures the sun's radiant energy and converts it to useful heat. It starts with an enclosure that surrounds the air and material to be heated. Solar energy passes through a clear or translucent material (usually a single pane of glass) on the enclosure's face and is absorbed by a matte-black surface—an "absorber plate." The absorber radiates the captured solar energy as heat into the cabinet, warming the air inside.

Courtesy www.geopathfinder.com

Most food dehydrator designs can be tailored to fit your needs.

SunWorks Solar Food Dehydrator



For food drying, the air entering the dryer needs to be heated to temperatures between 100°F and 150°F, and moved across the food to remove moisture. Heat does two critical things to speed up drying. First, it raises the temperature of the air, enabling it to hold more moisture. Second, it warms the food, increasing the "vapor pressure" of the liquid water in the food to increase the rate at which water evaporates into the surrounding air.

Air movement is the second essential element of drying. It carries the moist, saturated air away from the food and replaces it with drier, heated air that can absorb more water. Airflow should be kept at a rate that allows the air to be heated at least 30°F above the ambient temperature, assuring that the air will rapidly absorb moisture from the food.

Natural convection can be used to move the air, so no fan is needed. When air is warmed, it expands, becomes lighter than the surrounding air, and rises to the top of the dryer. If

Preserving Local Choice

Inexpensive fossil fuel has allowed us to have produce any time we want. Winter grapes and plums from Chile, peppers from Mexico, tomatoes from gas- or oil-heated hothouses, and apples and pears from refrigerated storage warehouses are abundant in grocery stores across the United States.

Although most of us don't yet feel the pinch in our pocketbooks from this energy-intensive (and inefficient) food supply, we're paying the price in other ways. Transporting food over long distances (1,500 miles on average) consumes vast quantities of fossil fuels—about 10 to 15 calories of fossil-fuel energy are put into our food system for every calorie of energy we get as food.

Plus, shipping generates large amounts of carbon dioxide (CO_2) emissions. In our increasing demand for freshness, food is being shipped by faster, more polluting methods. Airfreight generates 50 times more CO_2 than shipping by sea. Much of our "fresh" produce is picked unripe and then gassed to "ripen" after transport, or highly processed in factories using preservatives, irradiation, and other means to keep it stable for transport and sale—using even more energy.

Courtesy Eben Fodor

An alternative to this energy-hungry system is to expand the local food supply, supporting local farms, community supported agriculture groups, and farmers' markets. Some people stick to a "250-mile rule" for buying food, voluntarily limiting their food purchases to items grown within a 250-mile radius of their home. But when the growing season is over, what can you do to extend your self-reliance in a sustainable way? For many, solar food drying offers one efficient, renewable solution to this challenge.

Preventing Pests

The food in your dryer may pique the interest of a wide variety of animals and bugs, but proper design and a few tricks can keep them away. Screen all vent openings to keep out flies and yellow jackets. Sturdy construction and good latches on the loading door will stymie clever raccoons and other dexterous creatures. To prevent an ant or cockroach invasion, dust each leg of the dryer with diatomaceous earth, a popular nontoxic insecticide made from fossilized sea algae (diatoms), or place each leg in a container with an inch or two of water to make a moat.

Courtesy Appalachian State University

Well-designed through-pass collectors, like this Appalachian food dryer, are another solar food dehydrator design option.

we create an airflow pathway that allows cooler outside air to enter at the bottom of the dryer and warm air to exit at the top, we've created the necessary conditions for natural convection to work. The hotter the dryer gets, the faster the air will flow. Ideally, the airflow path should move across as much of the food as possible. A well-designed dryer will dehydrate food quickly—typically in one to two days. The operating principal of solar food dryers is different than "solar cookers" in that a flow of fresh air is encouraged in a dryer, and undesirable in a cooker, which requires higher temperatures.

Building It Right

Solar food dryers must be able to endure the elements and keep your food dry. Exterior-grade plywood should be used for the cabinet, and the legs should be made from rot-resistant wood or other materials that can survive ground contact. Treated wood should not be used in any part of the dryer that comes in contact with the food or your hands during loading and unloading.

Dealing with Humidity

Consider a muggy summer day of 85°F with a relative humidity (RH) of 80 percent. If left in the open, food would dry very slowly. At 80 percent RH, the air can absorb only a small amount of moisture before becoming saturated (100 percent RH). But heating this air to 120°F in a solar dryer reduces the RH of the air to about 28 percent, increasing its capacity for holding moisture almost threefold.

Any clear or translucent material that transmits a high percentage of solar radiation is a good candidate for the dryer's glazing. A single pane of clear, uncoated window glass is one of the best solar glazing materials. It transmits 86 to 92 percent of incident solar radiation and filters out most of the ultraviolet (UV) radiation, to help protect nutrients from degradation. It is better than plastic because it holds up well outdoors without yellowing or becoming hazy, is easy to clean, and can last indefinitely if not broken. Plus, it's inexpensive and readily available.

The screens for the food must be made from a mesh that allows plenty of airflow. They should also be made from an inert (nonreactive), food-safe material that can withstand temperatures as high as 200°F without stretching or sagging when loaded with food. Many available screen materials, such as galvanized metal and aluminum, are not suitable for food applications. Food-safe polypropylene screens are available, and are strong and easy to clean. They also come in various mesh sizes to accommodate different types of foods. Food-grade stainless steel screening is an option, although it's expensive and, in some dryer designs, may reflect some of the incoming solar energy, making the dryer less efficient.

The author's design, with extra mobile pest-control unit on patrol.

Courtesy Eben Fodor

DIY Solar Dryer Considerations

The best design will be ready to go when you are. It may sound appealing to build a dryer with a huge capacity, but a big, bulky dryer will be cumbersome to move and reposition toward the sun, require more materials, and be more expensive to build. Most people want units that are lightweight, easy to transport, and have little to no setup time.

A cabinet-type design with about 5 square feet (0.5 m^2) of glazing area, constructed with exterior-grade plywood and topped with a clear pane of window glass, can work well. Its capacity is plenty for most home users, and a direct-heating design speeds drying by boosting the effective temperature by about 20°F. The clear glazing allows you to visually monitor the food without opening the unit. Two large food trays made from lightweight aluminum frames with polypropylene screens provide 10 square feet of drying area, enough capacity for up to 6 pounds of fresh food.

Be sure to size vents adequately to encourage good airflow through the dehydrator. Manually adjustable venting allows temperature control, and screening on openings keeps out insects and other critters.

If you're in a climate that experiences extended periods of cloudy weather during the drying season or want to dry foods in the off season, consider designing your dryer with backup electric heating. Incandescent lightbulbs mounted inside the box can serve this function well.

A cabinet-type dryer can be built in a weekend. If you use new materials, the complete dryer, with an adjustable vent and backup heating, can be built for about $170. For even greater savings, get resourceful and construct your dryer from reclaimed materials. Use screws to assemble the pieces to make repairs and replacing parts easier.

A high-performance solar dryer will dry food quickly—on par with a good electric dryer. It will provide years of savings, along with the satisfaction of harnessing renewable sunshine. Solar food drying is a great way to discover the amazing power of the sun and is a truly sustainable solution for preserving healthy, high-quality, locally grown produce to enjoy all year 'round.

Access

Eben Fodor • sunworks@solarfooddryer.com • www.solarfooddryer.com

Instructions for making a SunWorks dryer are available in *The Solar Food Dryer: How to Make & Use Your Own High-Performance, Sun-Powered Food Dehydrator*, by Eben Fodor, 2006, Paperback, 128 pages, 0-86571-544-0, $14.95 from New Society Publishers • 800-567-6772 • www.newsociety.com

"The Design, Construction & Use of an Indirect, Through-Pass, Solar Food Dryer," Dennis Scanlin, *HP57*

"Improving Solar Food Dryers," Dennis Scanlin, Marcus Renner, David Domermuth & Heath Moody, *HP69*

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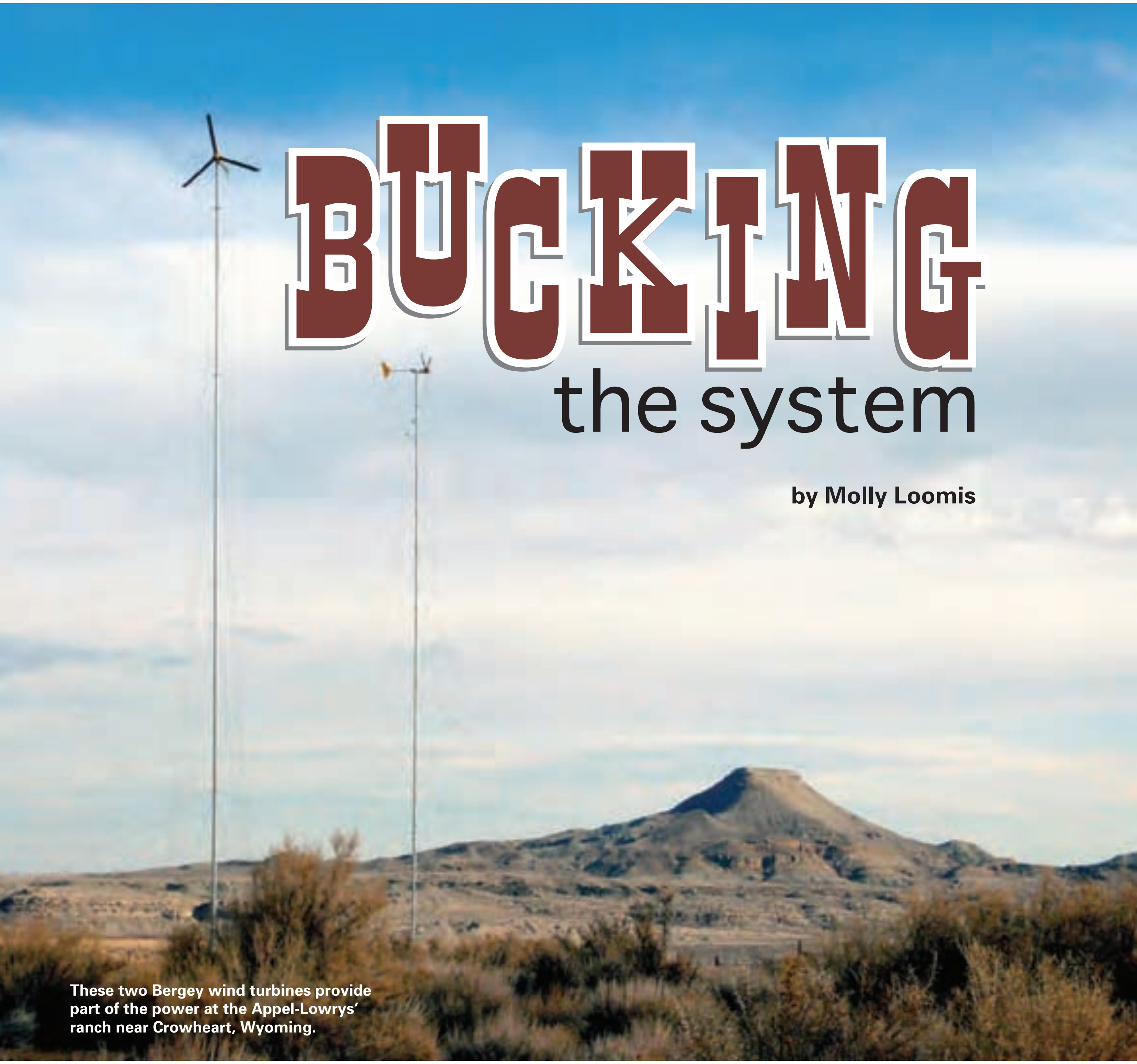
BUCKING the system

by Molly Loomis



These two Bergey wind turbines provide part of the power at the Appel-Lowrys' ranch near Crowheart, Wyoming.

Robert Appel has spent the past eighteen years working as a commercial jet pilot. But instead of living the globetrotter lifestyle many of his colleagues choose, Rob and his partner Marcia Lowry dedicate their time and earnings toward developing their off-grid ranch on the isolated sagelands of central Wyoming. These modern-day homesteaders are working to cultivate a sustainable lifestyle, relying almost exclusively on renewable energy (RE) technologies in a region dotted with oil derricks and dominated by King Coal.

From City to Sagebrush

Rob's interest in solar energy had its start while he was living in Phoenix, Arizona. "I remember looking up at the sun, and thinking, 'There has to be some way to use all that energy.'" In 1993, when the Appel-Lowrys moved to Rapid City, South Dakota, Rob dove right into his first off-grid renewable energy system—installing 24 Shell 75-watt (W) solar-electric (photovoltaic; PV) modules and a small Air-X wind turbine in the backyard.

Rob and Marcia's move from Rapid City to a 420-acre ranch outside of Crowheart, Wyoming, wasn't an impulsive move to a "gentleman's ranch," a growing trend in some parts of the West. Open Box P Ranch has been in Marcia's family since 1918. Founded in the early 1900s, it began as Willow Creek Creamery. When Marcia's grandparents acquired it, the land was used to raise sheep. Marcia had fond childhood memories of the ranch, and when her uncle, the previous resident, passed away, she and Rob took the opportunity to pursue a more self-sufficient lifestyle.

In the spring of 2005, Rob and Marcia officially changed their address to Crowheart and began the process of readying the century-old ranch house for renewables and planning extensive gardens and the collection of animals that were a part of their grand scheme for self-sufficiency. Marcia began work two miles up the road at the Crowheart Store—the local hitching post for gas, groceries, and gossip—while Rob commuted to local airports for his job as a pilot.

Above: Happy homesteaders Rob and Marcia, with their dog Luke.

Right: This PV array is one of several that provides electricity for the ranch.

off-grid *ranch*

A Modern, Rural Life

Because of abundant coal deposits in the state, Wyoming residents are supplied with some of the least expensive electricity in the United States, with an average residential cost per kilowatt-hour (KWH) of about $0.07. So Rob and Marcia's goal to disconnect from the utility grid befuddled some of the locals.

But Rob and Marcia were committed to make their ranch and lifestyle self-sufficient, and not rely on the utility grid or a large, noisy, polluting backup engine generator.

"Our whole goal is to be as sustainable as possible," Rob explains. And using renewable energy fit into their plan perfectly. Relying on the sun and wind for electricity—instead of coal-generated utility electricity—means that Rob and Marcia save almost 2 tons of coal from being burned each year, and almost 4 tons of carbon dioxide (CO_2), a gas that contributes to climate change, from being emitted.

Two solar collectors mounted on the roof provide almost all of the household's hot water. A small PV module (to the left of the collectors) powers the system's pump.

Marcia and the author peruse old photos of the ranch while enjoying the warmth provided by the pellet stove.

Home Loads (Heating Season)

Item	Avg. Hrs./Day	Watts (W)	Avg. WH/Day
Wood heater, blower	24.00	95	2,280.00
Well pump	1.20	1,800	2,160.00
Refrigerator	8.00	140	1,120.00
Pellet stove, blower	24.00	40	960.00
Freezer	4.50	130	585.00
Freezer	4.50	110	495.00
Electric blanket	3.00	117	351.00
Coffee maker	0.30	970	291.00
Toaster oven	0.20	1,360	272.00
Clothes washer	0.30	850	255.00
Stereo	4.00	60	240.00
Dining room lamp	8.00	30	240.00
Living room lamp	8.00	19	152.00
Microwave oven	0.20	750	150.00
2 Portable phones	24.00	3	144.00
2 Clock radios	24.00	3	144.00
TV, 27 in.	1.50	70	105.00
4 Kitchen lamps	1.00	23	92.00
Chicken house light	4.00	19	76.00
Satellite radio	18.00	4	72.00
2 Bathroom lights	1.00	23	46.00
Desktop computer	0.25	155	38.75
Laptop computer	0.50	65	32.50
Satellite dish	1.50	15	22.50
2 Bedroom lamps	0.50	19	19.00
Boom box radio	1.00	4	4.00
		Total Watt-Hours Per Day	10,346.75

Besides the positive environmental benefits of RE, it also offered the allure of financial independence from the utilities, instead of a lifetime of utility bills. "I get asked how could I spend so much money on a system. But it's not about saving money—or making money," Rob explains. "It's just something we wanted to do. It is so rewarding and satisfying.

"We prefer only to use what electricity we have—or do without. Living off the grid also means paying attention to the weather, which is the lifestyle we enjoy."

Getting Ready for RE

Rob and Marcia first tackled the efficiency upgrade challenges that come with a 100-year-old house. By using wood for space heating, and implementing efficiency and conservation measures, the Appel-Lowrys' monthly electricity use is a modest 240 to 310 KWH compared to an average American household, which uses at least three times that much. For cooking, Rob and Marcia rely on their wood heater and a propane range.

Besides upgrading household appliances to make their home as energy efficient as possible, the Appel-Lowrys practice energy-wise habits, like drying laundry on a clothesline outside and cooking with a Global Sun Ovens solar cooker, weather permitting. Implementing these low-tech fixes, says Marcia, has other benefits: "In the summer, using the solar cooker instead of the conventional oven keeps the house from getting too hot."

Sheep on the Appel-Lowry ranch provide wool for Marcia's knitting projects.

Four PV arrays generate electricity for the house and for water pumping. Power-conditioning equipment is housed in the insulated outbuilding behind the arrays.

"Folks have this perception that we must sit around by candlelight at night, huddled together. But we don't do without creature comforts. We just don't waste energy."

The wind turbines and their 82-foot-tall towers were raised into place with the help of a pickup truck.

Ranching with RE

From the start, solar electricity was a perfect match to support Rob and Marcia's ranching efforts. Abundant sunlight, especially during the summer months, made the decision to install a solar-direct water pump to irrigate their expansive vegetable gardens, a sheep pasture, and landscape plantings easy.

Four 160 W BP modules were installed just across the creek from the main house to provide electricity for a Conergy Solar Force piston pump, which moves water from Willow Creek and disperses it to their gardens, pasture, and the newly planted trees and shrubs that will one day serve as a windbreak. These days, during the winter, the array output is switched from the pump and routed to help charge the main RE system's 1,560 amp-hour battery bank.

Off-Grid...At a Glance

Location: Crowheart, Wyoming

Property size: 420 acres

Energy Systems

Solar-electric: 5.3 average daily peak sun-hours; 2.4 KW PV array, two Blue Sky Energy charge controllers

Wind-electric: 12.5 to 13.5 mph average wind speed at 33 ft.; Two Bergey XL.1 turbines on 82-ft. tilt-up towers, two Bergey PowerCenter charge controllers; Air 403 turbine

Balance of system: Xantrex SW4024 & Prosine 1800 inverters; 1,560 amp-hour Trojan L16 battery bank configured at 24 VDC; TriMetric battery monitor

Solar hot water: Two Heliodyne Gobi 4- by 10-ft. collectors, closed-loop glycol system; 120-gal. solar storage tank; Bosch tankless propane backup water heater

Energy production: 405 KWH per month average for wind- and solar-electric systems (100 percent of usage); 516 KWH per month average for solar hot water system (97 percent of usage)

Water systems: AC domestic water well pump; PV-direct Conergy Solar Force DC irrigation pump; rainwater harvesting and storage

Space heating: Wood heater & pellet stove

Cooking: Wood cookstove, propane oven/range, solar oven

In 2004, Rob installed the PV modules from the South Dakota home on pole mounts adjacent to the modules used primarily for water pumping. Next, a solar hot water system (two 4- by 10-ft. Heliodyne flat-plate collectors) was installed on the roof of the main house. The system provides close to 100 percent of the household's hot water. A Bosch propane on-demand water heater is plumbed in-line with the solar hot water system to boost the temperature of the solar-heated water when needed.

Wrangling the Wind

To cover their remaining electricity needs, and provide energy when the PV system doesn't—during cloudy weather and at night—Rob and Marcia decided to take advantage of the terrific wind resource at their site.

"I wanted to use both resources," says Rob. "The sun is much more reliable around here, but this way the two systems can complement each other."

Creative Energies, an Idaho- and Wyoming-based renewable energy company, installed two 1 KW Bergey XL.1 wind turbines on 82-foot-tall, guyed, tilt-up towers perched on a 65-foot-tall bluff just north of the ranch. The 400-watt Air-X turbine, which once sat in the Appel-Lowrys' backyard in South Dakota, now provides electricity for lighting and powering small appliances, like Marcia's sewing machine, in one of the ranch's small outbuildings. The turbine has been reliable and effective, with the only glitch involving Ramos, the Appel-Lowry's llama. The guy lines securing the turbine were his preferred scratching post, until one day he rubbed too hard and snapped a wire. Marcia has since put up a fence.

Scott Kane of Creative Energies tightens down the blades on one of the Bergey wind turbines.

Coming Together

The wind turbine and PV modules output is routed into the back room of an insulated outbuilding, where a 4,000-watt Xantrex SW4024 inverter and an 1,800-watt Prosine inverter (which powers the domestic water well pump) convert the DC electricity into typical, 120-volt household AC electricity. An adjacent, ventilated closet houses 16 Trojan L16 batteries, which store the electricity produced by the wind- and solar-electric systems. A TriMetric battery meter makes it easy to monitor the batteries' state of charge.

"As part of being off grid," says Rob, "our daily conversations include, 'What is the number?' We're referring to the TriMetric meter's 'amp-hours from full' number. Sometimes we have to conserve electricity—especially in the dead of winter with short days, no wind, no sun, and cold."

During other times of the year, the Appel–Lowrys have an abundance of energy, enough to run additional loads like an electric heater or food dehydrator. Over the last few years, they have only kicked on their 4,000 W backup engine generator twice.

Willow Creek, which runs through Rob and Marcia's property, provides water for livestock and irrigation.

System Costs

Item	Cost
Bergey XL.1 wind turbine with tower, installed	$8,000
Heliodyne SDHW system, installed	8,000
Bergey XL.1 wind turbine with tower, installed	7,200
24 Shell PV modules, 75 W	6,600
16 Trojan L16H batteries with cabling	5,700
4 BP 3160 PV modules, 160 W	2,800
Xantrex SW4024 inverter, 4,000 W	2,100
4 Zomeworks pole mounts	1,650
Conergy piston pump system, installed	1,300
Misc. electrical	1,100
2 Blue Sky Energy SB50 charge controllers	1,000
Wind datalogger, installed	940
2 combiner boxes	800
Prosine 1800 inverter, 1,800 W	600
2 Xantrex T240 transformers	560
Air-X wind turbine	380
TriMetric battery monitor	200
Total	$48,730

Off the Grid, Into the Fields

The Appel-Lowrys' commitment to sustainability doesn't end with their off-grid electric and water heating systems. They also grow the majority of their own food in their extensive gardens, raise their own chickens, sheep, and pigs, and harvest rainwater from the ranch house's metal roof into 300-gallon storage tanks for watering plants.

"Folks have this perception that we must sit around by candlelight at night, huddled together. But we don't do without creature comforts. We just don't waste energy."

Access

Molly Loomis • 208-354-0242 • molly_loomis@yahoo.com

Robert Appel & Marcia Lowry • mml245@wyoming.com

Creative Energies • www.creativeenergies.biz • RE systems dealer/installer

System Components:
Bergey Windpower Co. • 405-364-4212 • www.bergey.com • Bergey XL.1 wind turbines, controllers

Blue Sky Energy Inc. • 760-597-1642 ext. 101 • www.blueskyenergyinc.com • Charge controllers

Bogart Engineering • 831-338-0616 • www.bogartengineering.com • Battery monitor

BP Solar • www.bpsolar.com • PV modules

Conergy • www.conergy.us • Pump

Heliodyne Inc. • 510-237-9414 • www.heliodyne.com • Flat-plate solar thermal collectors

NRG Systems • 802-482-2255 • www.nrgsystems.com • Wind turbine towers

SolarWorld (formerly Shell Solar) • www.solarworld.de/sw-eng/products • PV modules

Southwest Windpower • www.windenergy.com • Air-X wind turbine

Sun Ovens International • 800-408-7919 • www.sunoven.com • Solar oven

Trojan Battery Co.• 800-423-6569 • www.trojanbattery.com • Battery bank

Xantrex • www.xantrex.com • Inverters

Zomeworks • 800-278-6342 or 505-242-5354 • www.zomeworks.com • PV array pole mounts

Wiley Electronics' ASSET

Acme Solar Site Evaluation Tool

by Joe Schwartz

Application:

The ASSET is a professional-grade, software-based solar resource evaluation and shading analysis tool. It's designed to provide system integrators with quick and detailed data for siting photovoltaic arrays, solar hot water collectors, and passive solar buildings.

The ASSET provides pro system integrators with a quick and accurate evaluation of a site's solar resource.

One of the first steps in the proper design of solar-electric and solar hot water systems, and passive solar buildings, is accurately analyzing the solar energy available at the site. Shading greatly reduces PV system output and, to a lesser degree, limits the energy production of solar thermal systems. Well-sited passive solar buildings, and PV and solar thermal systems, should make maximum use of the sun's available energy, and realistic system performance estimates are critical when setting a customer's expectations for their project.

Wiley Electronics' ASSET is one of three shading analysis tools available that performs computer-based shading analyses. It seamlessly integrates with the National Renewable Energy Laboratory's popular PVWATTS software, which includes 30-year solar insolation data for 239 U.S. locations.

Tool Overview

The ASSET consists of a digital camera, a camera positioning assembly, a USB camera-to-computer cable, and software, designed to run on either Windows or Macintosh platforms. (According to the manufacturer, the software will not run on Intel-based Macs at this time. A PC was used for this review.) No hardcopy manual is provided; instead, detailed step-by-step tool setup, use, and software guides are provided on the manufacturer's Web site.

The user typically takes a series of seven photos, spanning the potential solar site from east to west, and downloads these photos from the camera to his or her computer. The ASSET software creates a single panoramic image from this set of photos, and superimposes the sun's hourly path throughout the year over the image. Objects such as trees and buildings that will shade PV arrays or solar collectors are identified and quantified numerically. The available monthly and annual total sun-hour figures are calculated and displayed in the generated sun-path file.

Getting Set Up

The ASSET positioning system consists of a bubble level and compass mounted on a machined aluminum base. A standard 1/4–20 threaded mounting hole on the base accommodates a user-supplied tripod. The manufacturer recommends using ball-head tripods, which are generally fabricated from aluminum and won't magnetically interfere with the compass reading like tripods containing steel screws, springs, or pins can.

Once the base is mounted on the tripod, the bubble level is used to level the ASSET. The built-in compass allows for orientation to true south (in the northern hemisphere), and declination can be set on the compass based on the site's location. The camera and positioning system assembly, leveling, and orientation are straightforward and just take a few minutes.

Shooting the Site

Once the ASSET is set up at a given location, a series of either seven or nine photos is typically taken, starting in the east, moving through true south, and ending in the west. The assembly has a detent mechanism that makes positioning the camera for the next shot seamless and ensures smooth transitions between photos when the software creates the panoramic image. Shooting a series of photos takes less than a minute once the ASSET is assembled and oriented.

A seven-picture panorama will provide images from 75 degrees (15 degrees north of east) to 285 degrees (15 degrees north of west). The manufacturer recommends a seven-photo set for assessing shading for fixed PV and solar thermal arrays with tilt angles greater than 15 degrees and azimuths between 135 degrees (southeast) and 225 degrees (southwest). A nine-picture panorama sweeps a wider arc, from 45 degrees (northeast) through 315 degrees (northwest), and should be used for assessing sites for tracked or flat-mounted arrays.

The tripod-mounted ASSET makes quick work of shooting a panorama of seven or nine photographs.

The ASSET angle can be set at zero, 22.5, and 45 degrees while taking photos, with 22.5 degrees being the standard unless the site being evaluated has objects shading the location even when the sun is high in the sky. In this case, the ASSET allows for two panoramic images to be created, one above the other, with an additional row of site photos.

The manual notes that photos should ideally be taken either early in the morning or late in the afternoon, or on an overcast day to eliminate the possibility of camera glare. If you ignore this advice and shoot at midday in full sun, some glare will appear in the resulting images and the software's interpretation of shaded versus unshaded times of the day will be less accurate. This isn't a showstopper, but additional time will be required to adjust the brightness and/or contrast of the images to ensure accurate analysis. For the highest quality images, follow the manufacturer's advice if your site survey schedule allows.

Computer Analysis

The ASSET's software requirements are minimal: 300 MB of disk space and 512 MB of RAM are recommended. Your computer also needs to be equipped with a USB port for photo downloads from the camera.

Software is installed from the included CD, and free software updates are available on the manufacturer's Web site. (Software

Features

MSRP: $599

Warranty: Lifetime warranty on camera positioning system; 1-year manufacturer's warranty on digital camera

High Points:

Automatic calculation of shading data reduces the possibility of user error

Integrates with historical PVWATTS insolation data

Photo editing allows determination of additional insolation availability

Weighted data allows accurate analysis of non-south-facing arrays

Data can be imported into Excel or other spreadsheet programs for further comparative analysis

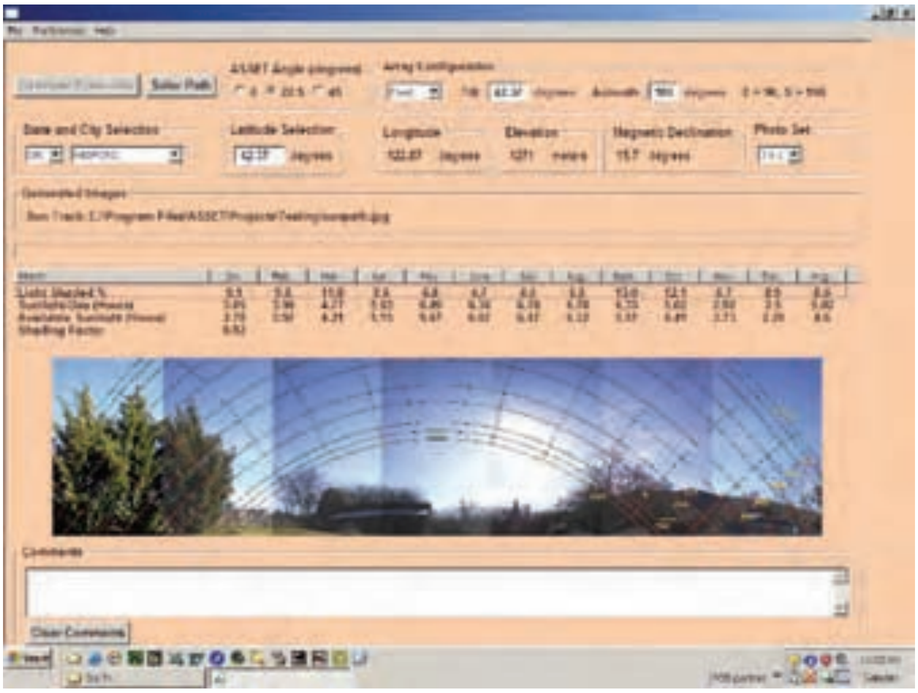
Durable hard-shell case protects equipment and keeps it organized

CSI–EPBB compliant (California)

Low Points:

Knurled screw that locks camera-positioning mechanism in place had a bit too much "play"

Tripod-mounted ASSET can be unsteady when working on roofs and moving between photo positions



The ASSET generates a panoramic image from a series of site photos and quantifies the solar resource available.

longitude, and elevation figures. The camera's positioning angle must also be set in the project preferences. In addition, array configuration options in the software allow you to choose between fixed and single or dual-axis tracked arrays. The tilt angle of fixed arrays can be specified between 0 and 90 degrees, and the azimuth can be set appropriately for non-south-facing arrays. Finally, you'll select the number of photos in your set.

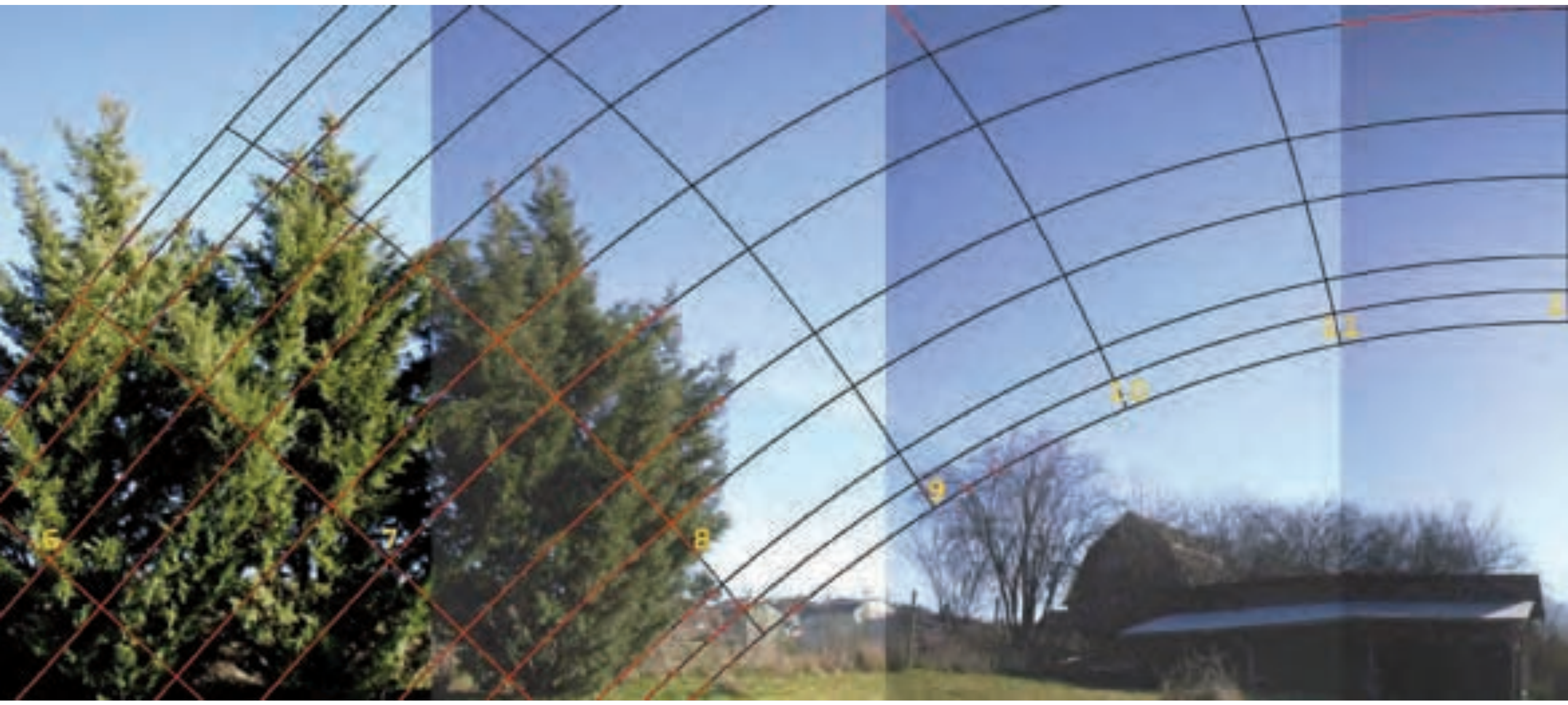
Once the project preferences have been configured, the next step is to browse and select the desired photo set. To ensure that the panoramic image is correctly assembled, make sure the photos stay in the order in which they were taken—from east to west for seven or nine image sets. Open the photos within the ASSET software application, and then generate the panorama, which will assemble the individual images into a complete site view. Clicking on the "Solar Path" button superimposes the sun path on top of the panoramic image, and generates month-by-month and annual site shading data. Each project is automatically saved after the sun path has been generated. The comments field provided is a handy feature for making site-specific notes.

version 1.27 was used for this review.) The installation adds an ASSET shortcut icon to your computer's desktop.

Once you've downloaded the site images to your computer, launch the ASSET software application. Selecting "New Project" from the menu initiates a new file, which needs to be named appropriately. Several project-specific preferences need to be set for each new site evaluation. "City and State" selection allows you to link your project to historical solar insolation data, and will also provide latitude,

Fine-Tuning the Photos

In a few instances, it will be either necessary or desirable to do some photo-editing work on the site images used to create the



panorama. If you have applications like Photoshop or iPhoto, you're good to go. If you don't, there are a variety of free image-editing programs that can be downloaded from the Web.

If the images are too dark or there is camera glare, the panorama may show portions of clear sky (free of shading obstructions) as shaded. Some of the inaccurate shading interpretation was left in the ASSET screen shot shown at left and the image below. This can be seen as red sun-path lines in the clear sky at the top of the panorama. Shading misinterpretation typically occurs when photos are taken on a clear day at midday, and glare is an issue. A few minutes of photo editing, adjusting the brightness and/or contrast of the photos using image-editing software, and rerunning the sun path will eliminate this issue, and generate accurate available sunlight and shading factors.

Photo editing may also be required if some objects, like trees and buildings, are within the sun path, but not shown as causing shading. In the example, the application incorrectly interpreted some portions of the evergreen trees (on the left side of the panorama) and the leafless deciduous trees (on the image's right-hand side). Adjusting the image's brightness and contrast will eliminate this unwanted effect.

One of the ASSET's most intriguing features is that objects that cause shading at the site can be removed from the image with photo-editing software. This allows you to get accurate, quantifiable data related to the additional solar exposure that would be available if trees or other plantings were removed or trimmed.

Automated Number-Crunching

Based on the panoramic image, sun path, and historical insolation data for a given site, the ASSET software automatically calculates a total solar shading factor, the potential insolation available per day in hours, and the available insolation based on shading at the site (this data is provided for each month of the year).

A spreadsheet-compatible .csv (comma separated values) file is also generated for each ASSET project, with data for shading for each hour of the day, averaged over each month. In addition, weighting factors, which quantify how much sunlight is received during different times of the day and the corresponding kilowatt-hour equivalency, are included. If you're skilled with Microsoft Excel or other spreadsheet programs, the data in the .csv file can be imported directly into more advanced, user-built spreadsheets to compare, for example, potential array output at different locations on a given site, or to calculate relative electricity generation and value during different times of day if time-of-use (TOU) metering is available or required by the local utility.

Accurate Performance Estimates

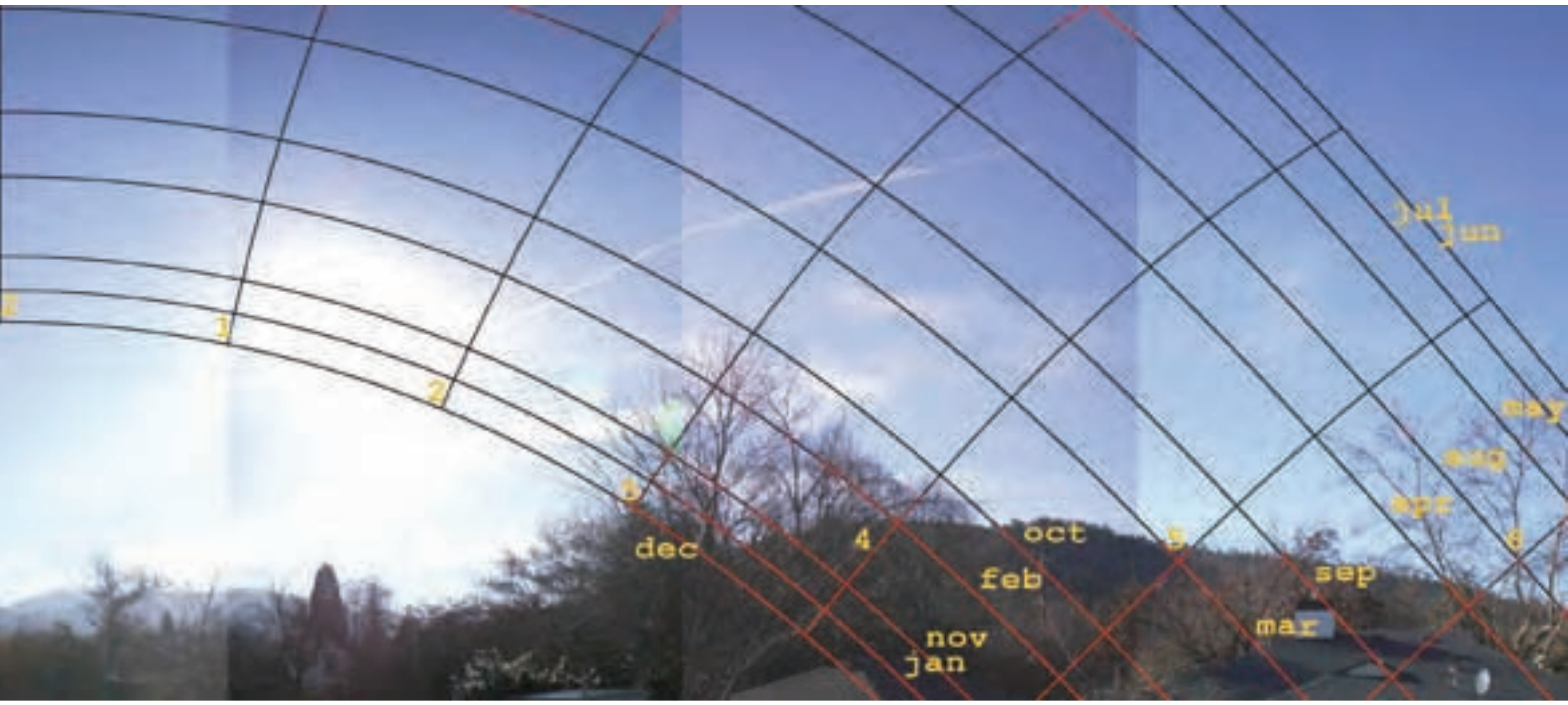
Even the best PV or solar thermal system equipment is guaranteed to underperform if excessive shading exists at the site. A thorough site analysis is an imperative initial step in system design and performance estimates. The ASSET is easy to use, allows for quick site surveys, and the level of data provided is invaluable for system designers and integrators. It takes any and all guesswork out of solar site surveys.

Access:

Reviewer: Joe Schwartz, *Home Power*, PO Box 520, Ashland, OR 97520 • joe.schwartz@homepower.com • www.homepower.com

Manufacturer: Wiley Electronics LLC • 845-247-2875 • www.we-llc.com

ASSET Distributor: Sunwize • 800-817-6527 • www.sunwize.com



©Steve Bischoff

by Shari Prange

In the market for a more efficient, emissions-free car? Electric vehicles can offer pollution-free driving at half the fuel costs of a typical gas-engine car. Here's how to find an all-electric rig that suits your needs.

While hybrid-electric gasoline vehicles get better fuel economy than their standard gasoline counterparts, they still produce tailpipe emissions and keep you tied to the pump. All-electric vehicles (EVs) offer a cleaner transportation option with no tailpipe emissions. And, if their batteries are recharged with renewable energy (RE), you can drive pollution-free.

EVs can also offer some economic savings. Depending on the drive system, they use about 0.17 to 0.4 kilowatt-hours (KWH) per mile. Multiply this by your local electricity rate to get the cost per mile. At $0.10 per KWH, an EV will cost $0.02 to $0.04 per mile for fuel. At $2.50 per gallon of gas and 25 mpg, that same vehicle using a gas-engine will cost you $0.10 per mile for fuel.

A typical EV can travel about 50 miles on a charge, and high-range EVs can go more than 100 miles. Recharging an EV while you're at work during the day can extend its daily commute range by 50 percent or more. In the worst cases, a very heavy EV, or one used in severe conditions, might only achieve 20 miles on a charge. But for many people, even that is enough to get to work or run errands.

"Driving an EV is as simple as turning the key and going down the road. There's no start-up, no warm-up, no fumes, no gas stations, and no engine noise to contend with," says EV owner Kevin Johnson, who commutes to and from work each day in his 1984 converted Volkswagen "Voltsrabbit."

Despite these benefits, there's a catch: All the major auto manufacturers crushed their electric vehicle programs—and physically crushed a slew of EVs—in the late '90s. If you're not game for converting a gasoline-engine car to an EV, that leaves one option—buying a used EV.

Where to Shop

EVs generally don't show up on your local used car lot, so you will have to search a little harder. The Internet is the place to look. Used EVs regularly appear on sites like eBay and craigslist. A few dedicated EV sales Web sites exist, and EV club and forum Web sites often list EVs for sale (see Access).

Before you buy, check out the Web site galleries of EV clubs and EV owners' groups that give details about their vehicles. Scanning some of these can help you clarify what type of vehicle would best suit your needs, and also give you an idea of the brands and models of components that are most common.

EV clubs and forums serve another useful function by allowing you to tap sources of expertise. Get to know some experienced EV owners—they tend to be very willing to help newcomers. Explain what your driving needs are and which cars seem interesting to you, and solicit their feedback. Finding and chatting with local EV owners—and scoping out their cars—can be an invaluable exercise for finding your own EV too.

Factory-Built Rides

Used EVs produced by the mainstream auto manufacturers—General Motors, Honda, Ford, and Toyota—are at one end of the EV spectrum. The only factory cars you're likely to find are Chevy S10s, Ford Rangers, and Toyota RAV4s, and possibly Th!nk Citys. These were the only models actually sold—not just leased—and only a few are in circulation. These models were manufactured during the mid-'90s through 2003, when the California zero emissions vehicle mandate was overturned due to heavy lobbying from auto manufacturers.

While these are reliable and well-made vehicles, beware of some pitfalls. Besides the RAV4 EV, which is still supported by Toyota, factory-built EVs and their parts and pieces are "orphans." The vehicles are no longer in production, and neither are their various model-specific components. If something goes wrong, you're on your own for finding a defunct twin vehicle you can harvest parts from.

In addition to the EV, you'll need its charging station too. Unfortunately, General Motors (GM) and Toyota used stand-alone, "paddle" chargers that were not on board the vehicle. Many of these chargers were originally installed in parking lots and businesses, but with the death of GM's EV program, have fallen into disrepair, been disconnected from power, or removed. The Ford Ranger had an onboard charger, but used a specialized connector called the Avcon instead of a standard plug. This situation can be resolved with an adaptor to allow use of normal electrical receptacles.

The Costs of Our Addiction to Oil

Our addiction to the internal combustion engine comes at a hefty price. Each year, American car owners shell out an average of $1,600 for auto fuel costs alone. This past year, most of us felt the pinch at the pump even more, with gasoline prices climbing an average of 208 percent above 2005 prices.

Besides taking a bite out of our budgets, gasoline cars have a mean streak when it comes to our environment and health. Scooting around town and across the country in our cars is one of the most environmentally damaging practices we do as individuals. Driving gas- and diesel-engine vehicles adds to local smog, which contributes to respiratory diseases among city dwellers, and creates a large portion of the greenhouse gases that cause global warming. In 2004, according to the Environmental Defense Fund, Americans' personal vehicles spewed out more than 300 million tons of carbon dioxide (CO_2), a greenhouse gas that contributes to climate change.

If you find one of these vehicles that interests you, see if you can locate an owner's group Internet forum for that EV model. Survey what kind of problems other owners have faced, and how they solved them. Some cars have dedicated enthusiasts who serve as a very useful support network.

Factory-built EVs are highly valued by the people who own them—and people who want them. Even models not in working condition can fetch a few thousand dollars. Vehicles in good working order can command prices between $30,000 and $40,000—or more.

©Ken Olsen

Above: The Chevy S10 is a commonly available electric pickup.

©Marc Geller

Right: Used RAV4 EVs, still supported by Toyota, are highly sought after—and this is often reflected in their prices.

©Dave Roden (2)

Solectria Force EVs were built on the engineless bodies of brand-new Geo Metros.

Small Company Production Cars

Several small companies produced electric vehicles from the 1970s through the early 2000s, usually in response to fossil-fuel distribution and supply issues. Some vehicles, like the CitiCar, Comuta-Car, and Tropica, were built from scratch as EVs. Others, like the Lectric Leopard or the Solectria Force, were factory conversions, where new gas-engine models were commercially converted on an assembly line and retitled as new cars "manufactured" by the company that converted them. The Leopard and Force were formerly the Renault LeCar and the Geo Metro, respectively. Because they are no longer in production, like the factory built-from-scratch models, these vehicles are orphans. Some can be dependable cars, but a little background research is necessary before you buy.

The Lectric Leopard, built in 1979 and 1980, should be singled out, as there are quite a few of them still around. They can make a decent, basic-level conversion, as long as you reconfigure the rear battery pack. The batteries in this design were inadequately secured, and could be lethally dangerous even in low-speed collisions.

During the same gasoline crisis period, Jet Industries performed several hundred conversions of Ford Escorts and Couriers. These were well done for their time, and can easily be upgraded with newer controllers and chargers to make decent modern vehicles. An electric Escort or Courier in good running condition might sell for $5,000 to $10,000.

An event like an oil crisis will always bring out some unsavory characters to exploit it, and EVs in this category were vulnerable. Some companies were very good at getting publicity and selling stock, but turned out mediocre cars with no standardization or documentation. In some cases, their vehicles were just warmed-over conversions actually done by someone else. If you're considering a car in this category, be sure to solicit opinions from electric vehicle club or forum members first, as they can warn you about some of these operations with bad reputations.

Kit-Built Conversion Cars

The most common electric vehicles you will find are gas-engine vehicles converted by individuals using kits. Two levels of conversion kits exist—universal kits and custom kits. Universal kits, which contain all the essential drive-system components but rely on the builder to create custom parts like battery racks or boxes, are most common. A vehicle built with a universal kit probably has decent-quality components, but buyers should pay particular attention to inspect the quality of workmanship on the wiring and battery containment.

Custom kits, which include the entire drive system, plus battery racks and boxes, are designed for specific vehicle models. If you find a vehicle built with one of these kits, you can be assured that the design has some track record, and the companies are still in business to offer support if needed. Canadian Electric Vehicles supplies custom kits to convert Chevy S10 trucks, Geo Metros, and Dodge Neons. My company, Electro Automotive, provides kits to convert Volkswagen Rabbits into "Voltsrabbits" and Porsche 914 models into "Voltsporsches."

These vehicles will range in price from a few hundred dollars for those in non-operating condition to $10,000 or more for ones in good running condition.

Know Your Needs

Before you go electric, first define what you want and need from a vehicle. Here's a checklist of considerations:

- How many miles do you need to cover on a daily basis, and what's the maximum range you need to cover before you can realistically recharge the EV's batteries?
- What speed do you need to attain? Is 65 mph fast enough, or do you need to go 85 mph to keep from getting run over on busy expressways?
- Do you encounter any severe-duty conditions, such as very cold weather, potholed roads, or steep hills, in your daily travel routine?
- Are you meticulous enough to faithfully check the electrolyte level in the batteries and top it off with distilled water, or should you look for a vehicle with sealed, maintenance-free batteries?
- Do you have reliable access to an electric outlet where you normally park?

Car-Shopping Checklist...

Car Credentials
Ask the seller to provide documentation for the EV you're considering. The more information they have, and the more understandable it is, the better. Owner's manuals, service manuals, receipts with part numbers, and wiring diagrams and notes will be useful if you need to do any repairs or maintenance on the vehicle. Wiring diagrams are particularly important if you ever need to troubleshoot or modify the vehicle. The less "mainstream"—and more customized—the vehicle, the more important the documentation is.

Batteries & Other Parts
Most used EVs are sold with dead or dying battery packs. If someone has been considering selling the car and moving on to something else (often another EV), the imminent need to spend $1,000 or so on new batteries, and do the heavy lifting, tends to tip the balance, and often motivates the sale.

Unfortunately, dying battery packs make it difficult to test-drive the vehicle, so you may have to take the seller's word on the EV's performance. Here's where consulting an experienced EV user can pay off, since he or she can most likely tell you whether the claimed performance seems realistic.

Beyond batteries, realize that the longer the car has sat unused, the more likely that there will be some hidden issues. For example, rubber or hydraulic parts may have deteriorated. If the car has sat unused for more than a few months, proceed with extreme caution.

General Condition
Besides inspecting the EV's battery and electrical systems, don't overlook the non-EV aspects of the vehicle. Is the body undamaged and rust free? Body damage can affect performance and indicate safety issues. Is the interior in reasonable shape? Convertible top in good condition? Fixing an EV's aesthetic issues, such as paint and upholstery, can get costly in a hurry.

Like orphan EVs and components, there also are orphan car makes. Beware of obscure car models or brands that have no dealer presence in your area. It could be difficult and costly to find basic parts for these cars.

Performance
Take the car for a test drive. Listen for odd noises, which will be very apparent in a silent EV. How does the steering and braking feel? Is it sloppy, does the car pull to one side, or take too long to stop? Test acceleration and handling on curves and hills. Will it be able to perform at safe speeds for the type of driving you will do? Can you climb hills and merge as needed? Does it feel tippy or want to wallow in corners? Overall, are you comfortable with the vehicle's performance?

Get a Pro's Opinion
If the EV passes your initial inspection with flying colors, take the car to an auto repair shop and have the basic running gear (brakes, suspension, wheel bearings, etc.) checked out. If the car isn't running, see if you can find a mobile mechanic who will inspect it on site. Getting a professional's opinion is well worth the $100 (or less) you'll pay for the inspection. If the owner has records or receipts for things like brakes and clutches, check these out too, noting how recently repairs and maintenance were done.

Custom-Built EVs
As a class of owner-built EVs in which components are typically mixed and matched, these vehicles have the most potential for problems and are difficult for EV newbies to adequately assess. You'll need to educate yourself about the EV's specific components to gauge their quality, or have an experienced EV advisor help you look them over.

Orphan or low-quality components may be mixed in with good ones. These vehicles may have an older- model speed controller or charger that was OK in its day, and it's not that difficult or costly to upgrade to a newer model. But upgrading an older motor will also mean getting a new adaptor to mate to the transmission. If the motor was an aircraft starter or generator, the vehicle would almost certainly need a major overhaul, including motor, adaptor, controller, and probably charger and other components, as these aircraft motors ran on lower voltage than is commonly used today. It would be easier to do a conversion from scratch than to upgrade one of these cars.

Beyond that, some simple advice will help cull custom EVs most prone to problems. First, avoid EVs powered by forklift motors, or aircraft starters or generators. These are inappropriate, and will only bring you grief. They will suck

The Voltsporsche is a custom-kit conversion of a Porsche 914.

©Shari Prange (2)

a lot of amps, which reduces range and stresses components, and they will not be compatible with most mainstream conversion components. Other obsolete technologies include speed control by series–parallel switching of the batteries, or SCR speed controllers, neither of which are very efficient.

Although orphan components are fine as long as they are working, be aware that if they fail, there's no support for them. This is most critical with controllers, chargers, and DC–DC converters. Avoid homebuilt controllers and chargers, which are usually invitations to trouble. Even if you find a well-built controller from a skilled and knowledgeable person, ask yourself whether she or he will be around to help you troubleshoot it if you have problems—or whether anyone else will be able to diagnose the creation.

Patience Pays Off

Used EVs span a wide range of prices—from basic owner-built conversions that cost a few thousand dollars to a mint-condition factory EV that may fetch tens of thousands. An EV's price generally reflects the running condition and aesthetics of the vehicle, its performance capabilities and pedigree (if it is a well-known and valued model, or uses well-known and valued components), and what the owner thinks it's worth.

You can probably get a sense of a factory car's value by doing a little Internet research. At any given time, you will probably find a few of each model for sale somewhere, and you can also get an idea of reasonable prices from owner's groups. To get a rough idea if a homebuilt conversion is "worth" the price, check out the current prices for a similar collection of components, and a similar donor car with a dead gas engine. Although installation labor is typically valued at $5,000, the previous owner has also benefited from several years' use of the vehicle, so those two items probably cancel each other out when figuring the value.

Buying a used EV takes more effort than buying an ordinary used car. Even if it seems like a great deal, don't feel pressured to grab the first EV you find, unless you know what to look for and it passes muster. Take the time to learn about the components, so you can make an informed choice to enjoy plenty of years of performance from your new-to-you EV.

Access

Shari Prange, Electro Automotive • 831-429-1989 • www.electroauto.com • Custom & universal kits, components

Randy Holmquist, Canadian Electric Vehicles • 250-954-2230 • www.canev.com • Custom kits, components

Roderick Wilde, EV Parts • 360-385-7082 • www.evparts.com • Custom kits & components

Used EVs for Sale:

Craigslist • www.craigslist.com • Listings of vehicles for sale

eBay • www.motors.ebay.com • Listings of vehicles for sale

Electric Auto Association (EAA) • www.eaaev.org • EV enthusiasts' club with chapters across the United States and Canada; Web links to EV sale sites

EV Finder • www.evfinder.com • Listings of vehicles for sale

EV Tradin' Post • www.austinev.org/evtradinpost • Listings of vehicles and components for sale

Online Discussion Lists:

Solectria Discussion Group • www.groups.yahoo.com/group/solectria_ev

RAV4 EV Owners Discussion Group • www.five.pairlist.net/mailman/listinfo/rav4-ev

Electric Vehicle Discussion List • www.madkatz.com/ev/evlist.html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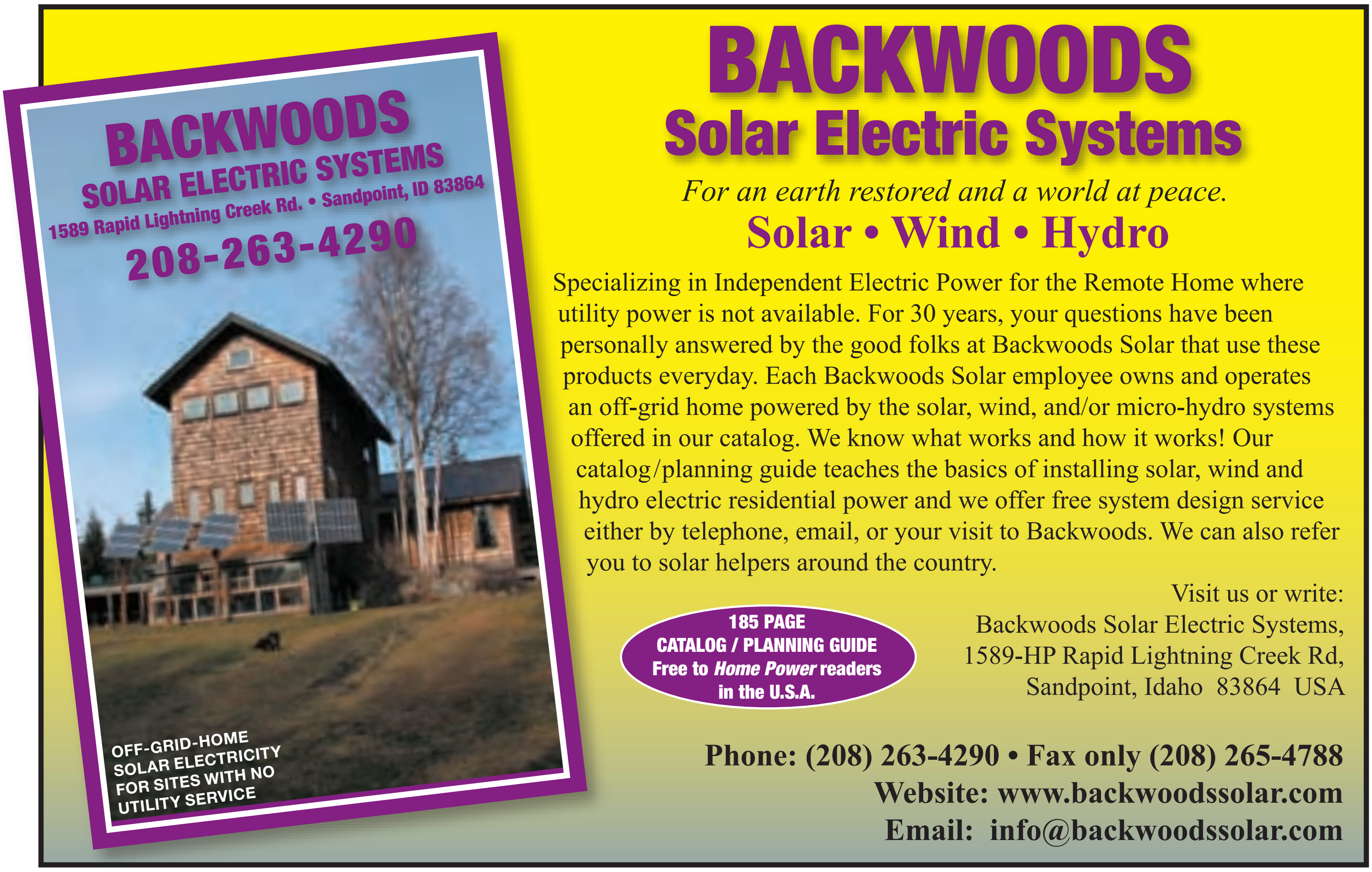
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Email: info@backwoodssolar.com

Solar Heat UPGRADE

by Guy Marsden

Expanding & Improving an Owner-Installed System

The author with his expanded solar thermal system that provides heat for his office and workshop.

Can a solar thermal heating system keep you warm, even if you live in a location with harsh winters like here in Woolwich, Maine? You bet it can. In 2001, I installed a solar thermal system to heat my workshop and office (see *HP89*). After living with the system for almost six years, I've definitely learned several interesting lessons. If you want to improve the performance of your solar heating setup, or get started on the right foot before you install your system, here are some pointers.

Solar Collector Upgrades & Additions

My original solar heating system was designed by a local solar energy system designer and equipment supplier. Since I'm handy with both plumbing and electrical work, I decided to install it myself. The system parts list included two SunEarth 4- by 8-foot Empire series collectors, a Secespol B 130 heat exchanger, two El-Sid PV-powered circulator pumps, and a Rheem 80-gallon storage tank. For backup heat during extended cloudy periods, I installed a Bosch AquaStar instantaneous gas-fired water heater in series with the solar thermal system output. The system heats a well-insulated, 24- by 28-foot building with a radiant slab on the ground floor where my woodworking equipment is located. My electronics lab/office is on the open second floor and was originally heated by convection from the first floor slab, with hot air rising up the stairway and through the open door at the top.

A few months after I had finished installing the system, my system designer informed me that the collectors I purchased had a design flaw that would cause them to underperform. I was seeing a maximum collector temperature of about 180°F on bright sunny days. SunEarth offered to replace the

collector absorber plates, and at the same time I decided to also add two more collectors to the system. These changes resulted in peak collector temperatures of 240°F on similar days—a dramatic improvement!

Getting the Pumps Under Control

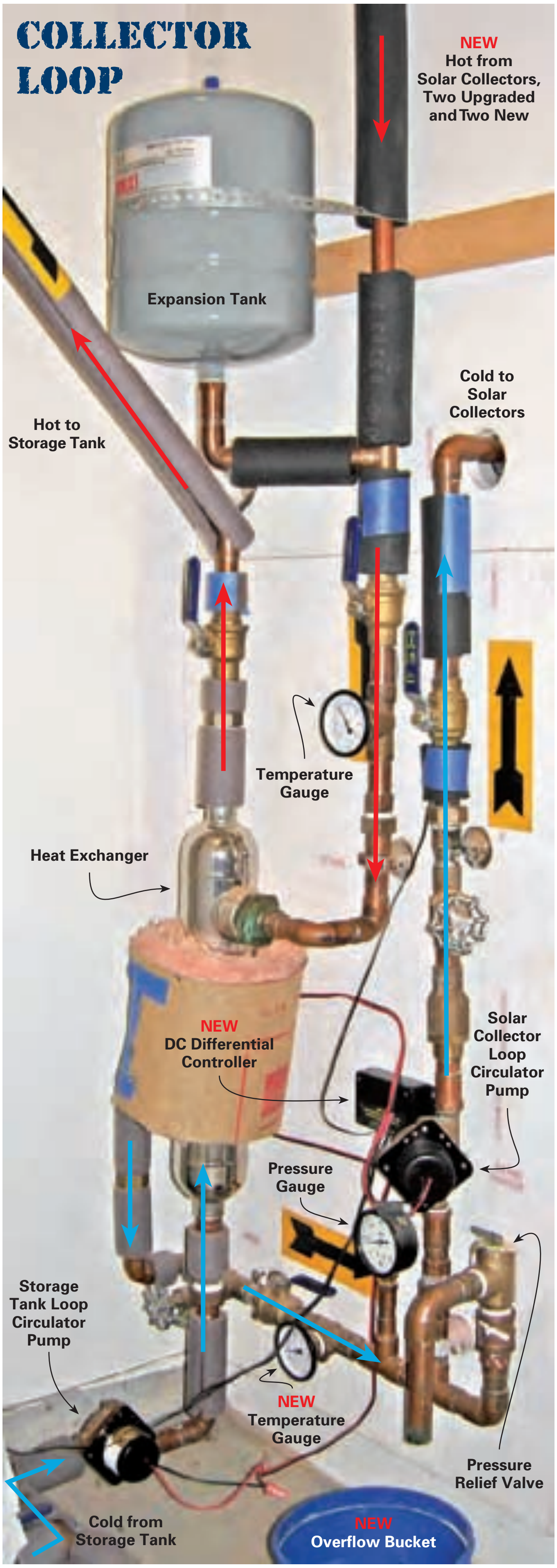
Both the collector loop and the loop from the heat exchanger to the solar storage tank used solar-direct pumps without controllers. Whenever the sun was shining, the solar-electric (photovoltaic; PV) modules powered the circulator pumps. Each of the two 10-watt pumps was powered by 20 watts of PV.

This seemed like an elegant solution. But after observing my system for the first year, I noticed that the storage tank temperature would drop considerably within an hour of sunset, and also in the early morning. As the sun went down, the collectors became cooler than the storage tank. I finally realized that the hot water stored in the tank was being radiated out through the collectors (via the heat exchanger) because there was still enough sun to run both of the PV-powered circulator pumps.

Most solar thermal systems use a controller to prevent the pump from running when the collector fluid is cooler than the stored hot water. In my system, the collector-to-heat-exchanger pump is direct-wired to the PV module without a controller, and is not a problem. But the second pump, which circulates hot water from the heat exchanger to the storage tank, needs to be controlled to prevent heat loss and maximize system performance.

While affordable, high-quality differential temperature controllers are readily available, the ones I found all run on 120 VAC. It didn't seem appropriate to run the DC PV-powered pumps with an AC-powered controller—what if the grid fails, as it does often here in rural Maine? This would leave my heating system crippled until utility power was restored.

As an inventor and an electrical engineer, I decided to build my own controller that would run on 12 VDC from a PV module. Sensors on the collector outlet pipe and one near the top of the storage tank are wired to the controller, which only activates the heat exchanger-to-storage-tank pump if the collector fluid is hotter than the stored water.



A DC-powered differential controller, designed and built by the author.

More Heat for the Second Floor

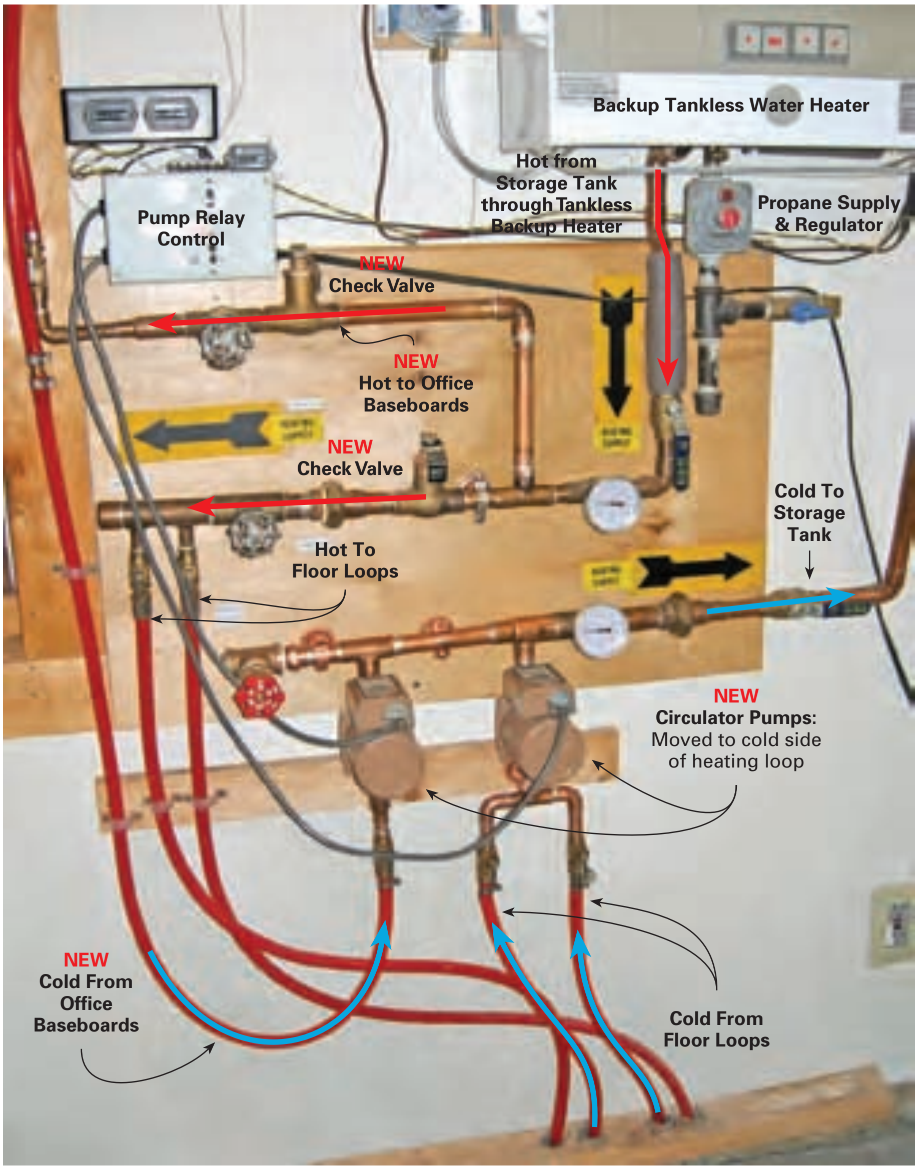
With my original system, the second floor office was a bit chilly in the mornings, since I had to wait for the heat to rise through the open stairwell. To remedy this, I added two 10-foot-long hydronic baseboard radiators upstairs.

Installing them was fairly simple. I ran 1/2-inch PEX radiant floor tubing from the main heating system manifold to the new radiators and back. (Copper tubing would have been fine as well—but the PEX is so easy to work with!) To minimize heat loss in the new plumbing runs, I insulated the exposed tubing with high-density foam pipe insulation. Since the radiators are on the second floor, I had to move my automatic air vent up to the new highest point in the hydronic system, which was right at the end of one of the radiators.

When I first ran the separate circulator pump for the radiator loop, I found (by feeling the pipe) that the water going to the radiators was not hot. Some models of circulator pumps have built-in check valves, but mine didn't. I discovered that the pump was pulling cold water in a reverse flow from the floor loop, instead of directly from the storage tank, so I installed a couple of check valves to keep the water flowing in the right direction in each loop.

Installing a larger expansion tank eliminated overpressure problems.

HEATING LOOP

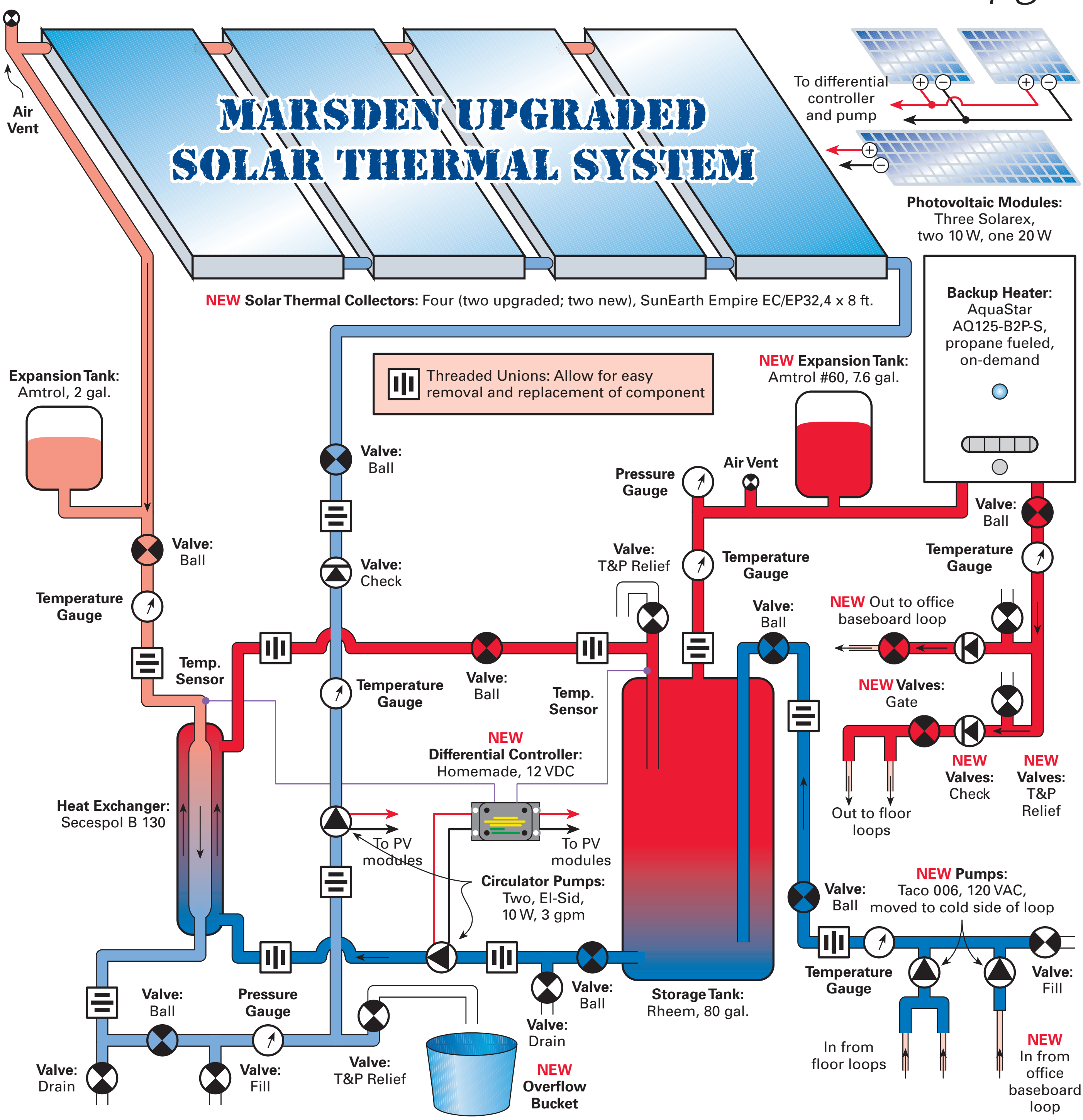


When I turn on the upstairs thermostat now, the radiators get 140°F water right away and the room temperature rises by about 6°F per hour—even when temperatures outside dip below 10°F.

Of course, the system has its limits. Despite the tight, well-insulated building envelope, the design of my heating system just can't keep up when it's well below 0°F outside. We had a record –20°F this winter, and even with the propane backup heater running day and night, the system could not maintain the 65°F setting on the thermostat. Once the outside temperature got above 10°F, the system operation returned to normal.

Reorienting the Pump

Occasionally in the mornings, I'd find the building more than 5°F below the 65°F thermostat setting, indicating a performance problem with the system. Listening to the circulator pumps, I would hear a gurgling sound that made me suspect that there was air trapped in the pump. This is called cavitation, and it can prevent the pump from working



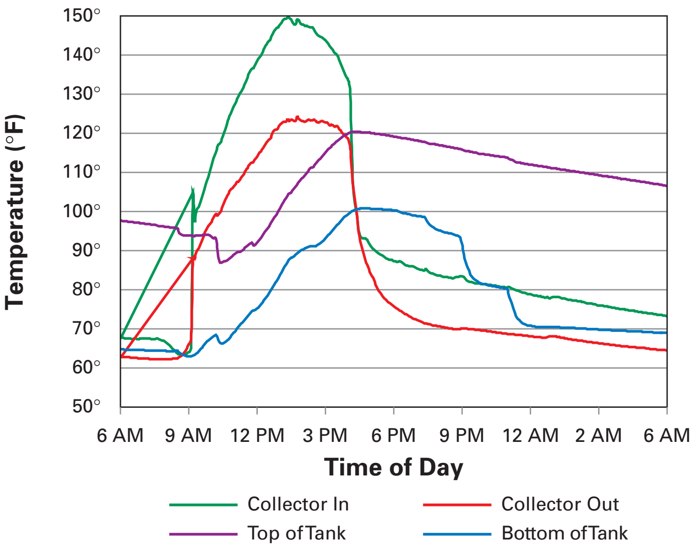
or even cause irreparable damage in some cases. Through ignorance, I had oriented the pumps horizontally (the fluid entered and exited from the sides), which increases the incidence of cavitation with some pumps.

So I replumbed the whole manifold, reorienting the pumps so the flow is vertical. This allows trapped air to escape to the highest point of the hydronic system, so the automatic air vent can eliminate it. In the replumbing process, I also moved the pumps from the feed side of the heating loops to the return side. I did this on the recommendation of a very helpful applications engineer at Taco. He said that the pumps would last longer if they were installed on the cooler side of the loop.

Dealing with Excess Heat & Pressure

During the early spring through the late fall months, the system produces more heat than I need. I've had various suggestions for solutions to this issue from a number of solar hot water system dealers who read my previous *Home Power* article. Suggestions included installing a thermostatic three-way valve that dumps heat to an outside radiator during the warm months, and covering the collectors with canvas boat

Winter Solar Thermal Collector Performance



covers. I have yet to implement these suggestions—I simply drain and flush the collector loop in the spring and refill it in the fall.

High temperatures in my storage tank used to drive the pressure to more than 100 psi, which once caused the pressure-temperature relief valve at the top of the tank to blow and dump hot water all over the place. My simple, stopgap solution was to place a gallon bucket under the outflow!

After struggling with this issue for more than a year, I read a brief article by *Home Power* solar thermal editor Chuck Marken about expansion tanks, which give solar water heating systems "elbow room" by regulating system pressure so the relief valve does not need to open to release excess pressure as the water gets hotter. When it dawned on me that the expansion tank might be undersized for my system, I asked Chuck, who pointed me to the expansion tank sizing calculator at the Amtrol Web site (www.amtrol.com).

The calculator confirmed that my expansion tank—a #15 with a 2-gallon capacity—was undersized. Based on my system specs, Amtrol recommends a #60 tank with 7.6-gallon capacity. At a cost of about $90, I replaced my tank, and the solar storage tank's pressure has remained relatively constant ever since.

Frozen Pipes

Last winter, record low temperatures of -20°F caused my collector plumbing to freeze somewhere in the 15-foot-long, insulated (but outdoor) plumbing to the bottom of the collectors. It turned out that when I had filled the collectors in the fall, I had miscalculated the 50 percent ratio of propylene glycol needed, and had only used a 40 percent glycol mixture. I had to drive through a heavy snowstorm to the local plumbing supply warehouse to get an expensive 5-gallon container of antifreeze.

By mid-afternoon, the ambient temperatures were up to 10°F, and I was able to use my fill pump to unblock the frozen plumbing by forcing fluid into it until the heated collector fluid cleared the pipes. I then drained some fluid and pumped in a healthy dose of antifreeze. I used a chart provided by the antifreeze manufacturer to figure out what ratio would protect pipes to -20°F in the future.

Warm in the Winter

After these small tweaks and some fine tuning, I am very pleased with the performance of my solar-augmented heating system. I keep the building at 65°F downstairs and 72°F upstairs through the Maine winters, and have had relatively few problems for a home-built design. We certainly do get a lot of clear sunny days in the colder months—parts of Maine have almost as much annual solar insolation as New Orleans—and the solar collectors definitely contribute to a significant savings on propane.

With the supplemental solar heating, my propane bills—at $1.49 per gallon—averaged $140 per month for the five months of winter weather during 2004–2005. The following winter, due to warmer weather and the additional heat from a newly installed wood heater, bills averaged $100 per month. That's not bad in this climate for a building of more than 1,300 square feet!

Access

Guy Marsden, 61 Delano Rd., Woolwich, ME 04579 • 207-443-8942 • Fax: 866-427-8832 • guy@arttec.net

System Components:

Art Tec • www.arttec.net • Differential temperature controller

Ivan Labs, 350 Circle W., Jupiter, FL 33458 • 561-747-5354 • El-Sid circulator pumps

Rheem • www.rheem.com • Solar storage tank

Secespol • 905-602-4505 • www.secespol.com • Heat exchanger

SunEarth • www.sunearthinc.com • Collectors

Taco Inc. • 401-942-8000 • www.taco-hvac.com • Circulator pump

RE-SOURCES Energy Fairs

Summer is the time for basking in the sunshine—and learning how to put it to work for you! Renewable energy fairs offer the perfect opportunity to get the scoop on the latest gear, take advantage of free educational workshops, and tap into RE expertise in an easy-going, casual (and often festive) atmosphere. Many events also are family-friendly, with activities specifically designed to kindle young ones' interest in all things solar. Admission to these events is friendly as well—for the cost of a night at the movies, you can get your solar start, have a great time with other like-minded folks, and maybe even walk away with sweet deals on renewable energy equipment.

June

▶ Rhode Island Sustainable Living Festival & Clean Energy Expo
Coventry, Rhode Island; June 9
www.livingfest.org

▶ RE & Sustainable Living Fair (aka MREF)
Custer, Wisconsin; June 15–17
www.the-mrea.org/energy_fair.php

▶ Michigan Energy Fair
Onekama, Michigan; June 22–24
www.glrea.org/events/MichiganEnergyFair2007/

July

▶ SolarFest
Tinmouth, Vermont; July 14–15
www.solarfest.com

▶ Shoreline Sustainable Living & Renewable Energy Fair
Shoreline, Washington; July 21
www.shorelinesolar.org/fair4/fair.php

▶ SolWest
John Day, Oregon; July 27–29
www.solwest.org

August

▶ Southern California Renewable Energy Expo
Pomona, California; August 4–5
www.socalenergyexpo.com

▶ Illinois RE & Sustainable Lifestyle Fair
Oregon, Illinois; August 11–12
www.illinoisrenew.org/events/fair.htm

▶ SolFest
Hopland, California; August 18–19
www.solfest.org

▶ Southern Energy & Environment Expo
Fletcher, North Carolina; August 24–26
www.seeexpo.com

September

▶ Iowa Renewable Energy Expo
Solon, Iowa; September 8–9
www.irenew.org/expo.html

▶ Northwest Solar Expo
Portland, Oregon; September 14–16
www.nwsolarexpo.com

▶ Rocky Mt. Sustainable Living Fair
Fort Collins, Colorado; September 15–16
www.sustainablelivingassociation.org/fair/

▶ Solar Fiesta
Albuquerque, New Mexico; September 15–16
www.nmsea.org

▶ Pennsylvania RE & Sustainable Living Festival
Kempton, Pennsylvania; September 22–23
www.paenergyfest.com

▶ Ozark Renewable Energy & Sustainable Living Expo
Columbia, Missouri; September 22-23
www.ozarkre.org

▶ RE Roundup & Green Living Fair
Fredericksburg, Texas; September 28–30
www.renewableenergyroundup.com

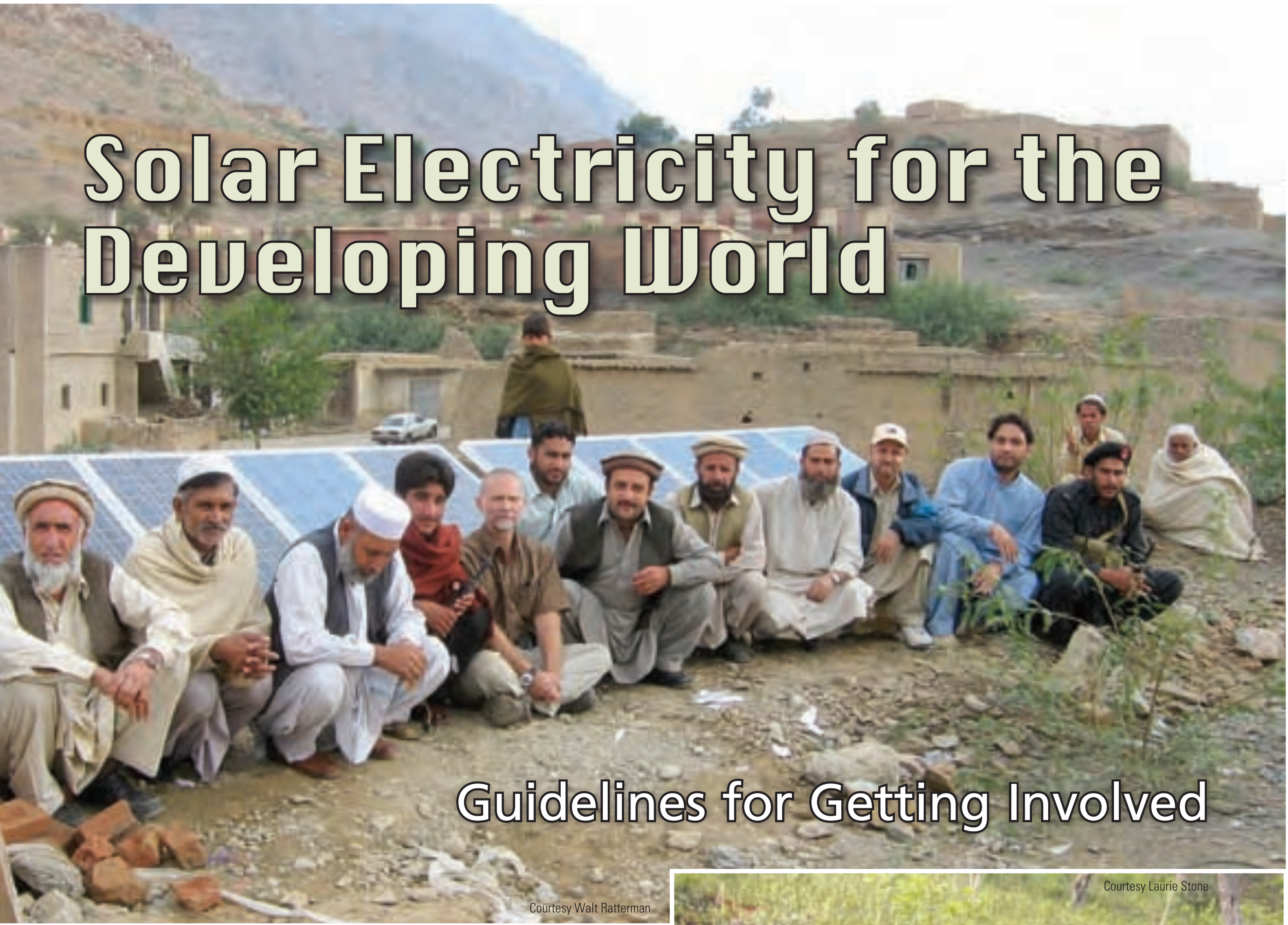
For the Pros & the Public

RE industry professionals and those who want to launch their RE careers will want to mark their calendars for two particular industry events: Solar 2007 and Solar Power 2007. Attendees can choose from a variety of training opportunities and short workshops, and browse a diverse array of exhibits in the expo halls. Both events are also open to the public, and offer consumer-focused workshops.

▶ Solar 2007
Cleveland, Ohio
July 7–12
www.ases.org/solar2007

▶ Solar Power 2007
Long Beach, California
September 24–27
www.solarpowerconference.com

Solar Electricity for the Developing World



Guidelines for Getting Involved

Courtesy Walt Ratterman

Courtesy Laurie Stone

Above: The author (fifth from left) worked with villagers from tribal lands in Pakistan to install this PV array, which powers a water pumping system. Right: A Ecuadoran woman assembles a PV module rack.

by Walt Ratterman

If you want to travel to exotic places and install solar-electric systems in the developing world, you're not alone. Those of us in this field get requests almost daily from people who want to get involved. But what does it take to truly help people in less-developed countries begin to use solar electricity in an effective and lasting way? The simple answer is that training *yourself* is as important as training others.

Right: Small rooftop PV systems at this Buddhist monastery in Arunachal Pradesh provide electricity for lighting.

Below: Community members from a village in northern Thailand learn how to use a digital multimeter to test a PV module's output.

Courtesy Andrew Pascale

Courtesy Walt Ratterman

Local Choice

Working on renewable energy projects in the developing world can mean installing interesting systems, traveling to new and exciting places, and sharing your knowledge. But this work is really about helping people improve their lives in a way that *they* choose.

For example, one organization I'm involved with does a lot of work with the Shuar people in Ecuador. Before we start a project, we travel to the village and teach the local residents the basics of efficient energy use and management, and develop an energy budget for their community. Recently we worked in two similar Shuar communities, both of which were far from the utility grid. One community decided they did not want to put individual solar-electric systems on their houses, but instead chose to develop a centralized installation on a clinic to power an emergency radio system, community center, and a public battery charging system. The other village chose to electrify their individual homes, and decided to raise additional funds so they could also provide electricity for their school.

To do this kind of work successfully, you should first understand that you're not helping people who are in any way *less* than or *behind* us. In fact, in most ways that are important to individual survival, people in these cultures are often light years ahead of us. The abilities of these groups to

Thai medics configure small-scale solar-electric systems for their clinics.

Courtesy Walt Ratterman

PV Differences

Here in the United States, solar-electric (photovoltaic; PV) systems typically consist of modules on our roofs, connected to the utility grid to generate some portion of our household electricity. But in many parts of the developing world, solar energy is the *only* source of electricity for a home or a village, because no grid exists.

In the States, average-sized residential solar-electric systems are between 3 and 5 kilowatts (KW). In the developing world, systems of that size could run an entire *village* or a large community health center. Average home systems in the developing world are 50 to 75 *watts* (W), and "large" systems may be 120 W—a fraction of the size of a typical residential system in the United States.

Courtesy Walt Ratterman (2)

The Solar Electric Light Fund sponsored PV systems in Rwanda to provide much-needed electricity for community hospitals.

build large structures with simple hand tools, and to be able to identify and treat most illnesses with plants that grow in the jungle is amazing. Approach these projects realizing that in all likelihood, you will learn far more about yourself than the people you are helping will learn about renewable energy.

Quality Control

Bringing renewable energy systems to developing areas cannot be done in a hurry—at least not correctly. Since the technologies are new to those you are working with, you'll need to impart your knowledge to them in a way that will enable them to troubleshoot and maintain their systems. It is easy to go to a village with a couple of horse-loads of equipment, install a few systems, and leave. But the systems won't last.

In my travels, I have come across numerous systems that were installed by placing a module on a roof, nailing a charge controller to a wall, and stringing some wire along the beams—with no attention paid to the climate, the durability of the installation, or local training to properly use and maintain the system. I am usually informed that the system worked for anywhere between two and six months before it failed.

When it comes to installing systems in the developing world, we hear a lot of comments like, "Well, at least we don't have to pay attention to the code when we are overseas..." In most respects, we need to pay *more* attention to the issues raised in the *National Electrical Code* or other standards, because they are developed to produce safe and reliable

The author teaches PV basics to Burmese refugees in Thailand with the Border Green Energy Team.

Left: A Cuban video center.

Courtesy Danny Lenain; left: Courtesy Cubasolar

Volunteers and villagers work side by side to install a PV system that will provide electricity for refugee camps.

systems. These should actually become minimum standards in developing-world PV applications, and not something we can conveniently avoid.

For example, in many installations I've seen, the installer did not pay any attention to the use of weather-tight junction boxes for wiring terminations, or use strain-relief connectors on cables going into enclosures. Most of the wiring failures we see occur at terminations. Adhering to first-rate wiring practices goes a long way to making the system last.

Training is Crucial

Lots of well-intentioned people want to go overseas and "install systems for folks." In many ways, that is the worst favor we could do. Are you going to leave your cell phone number for them to call when a wire comes loose? So besides providing training in the basic concepts of solar electricity, we train people to install systems properly. That way, they know how to work on them after we've left.

When the local crew finishes installing a system and has their celebration the night before we leave, we spend some time sabotaging the installation. We remove wires, switch connections, and even short out wiring. In the morning, when we are asked to fix the systems, we instead watch as the newly trained installers do the troubleshooting.

Courtesy Laurie Stone

A PV installation in the mountains of Peru.

Misconceptions About RE Work in the Developing World

"Our job is to help them…"
This is a two-way street—we need to be open to learning as much (or more) than we are able to teach.

"The people we are teaching are primitive."
The people in these situations are highly skilled with their hands and with their concepts of what it takes to make things work. We just need to teach them about the technology.

"The problems related to developing-world projects are mainly technical."
The technical issues were resolved long ago. Aside from funding, the important work is matching appropriate systems to a community's needs and providing the community with training for the ongoing maintenance of the systems.

"Now that I have taken a class in renewable energy, I can try out the real work in a remote community."
Until you've worked on many installations with success, consider yourself an apprentice.

"The work is simple."
Although the technical work is not difficult, planning and executing a project is complex. Load analysis, design, and community expectations all come into play.

"The work is quick."
Projects typically take several times longer than in the States, mainly because of the degree of training that we must do.

"Once the system is complete, we are finished."
We need to be sure that procedures have been established to address problems and maintenance. Nothing works forever, and community members need to be able to service their systems once we depart.

"We only need to visit the project once—to do the work."
Generally, it is best if we can make one or more preliminary visits to the community to assess the site, examine the loads, and gauge local interest and ability.

"This will be a good way to make a living."
This is a work of love and commitment, most often done by volunteers. Though there are career possibilities, they are not common, and generally not entry-level.

Refugees at a camp on the Thailand–Burmese border install an inverter and charge controller.

Managing Loads

Beyond maintaining the systems, perhaps our biggest job is to help system users understand load management—how much energy they have at their disposal over a given time period. If you tell folks that the batteries are designed to support their electrical load for three days, what are they supposed to do when there are four days of clouds? Or even when there is only one day of clouds? Finding approaches to get these ideas across in a way that makes sense to people who have never lived with electricity, and in a way that they can relate to and remember, is crucial.

When we install systems in the developing world, we go through a lot of examples showing how the battery never gets recharged unless system users keep the loads off. We teach them that for every day that is cloudy, they must leave the system off (or nearly off) for a day.

Fostering Ownership

While the trainings cover how solar-electric systems work, they also need to include fiscal management strategies—how much money the community needs to allocate for maintenance and battery replacement. This training ultimately involves community development and community resource management. For RE systems to last in the developing world, their users need to be well equipped—both with technical skills and the financial means—to maintain them.

Systems are expensive, and most families living far from the grid are poor and can't afford to purchase a system outright. Do we offer them a gift? Do we offer them credit? How do we set up a system so that community members can put money into a fund each month to pay for replacement batteries when they eventually fail?

The answers to these questions are different for each community. We have to be ready to work with the people, understand their needs and their culture, and be able to recommend solutions that work within that framework.

Where to Begin

Besides learning how to effectively communicate and work with cultures that may be vastly different than your own, mastering the technical work first is essential. Many organizations, such as Solar Energy International (SEI) and the Midwest Renewable Energy Association, offer extended workshops in renewable energy systems. See Laurie Stone's article on RE education options in *HP116* for more good places to start.

After the coursework, getting practical, hands-on experience is critical. For instance, to be able to show someone else how best to connect wires to a charge controller, you need to have figured out all of the *wrong* ways to do it already. You can only get this experience by working with similar systems here in the States, or as a helper overseas.

Once the technology is under your belt and you have taken a good dose of humility, finding a place to learn the people side of things might be more of a challenge. A good first step is to find a nongovernmental organization (NGO) based in the country where you want to work, especially one that is doing RE work already. The best way to locate these NGOs is by searching the Internet for them, as well as networking with people you meet in RE workshops and events. SEI's INVEST (International Volunteers in Environmentally Sustainable Technologies) program helps pair SEI alumni who want to volunteer in the developing world with organizations there.

Mutual Gain

Although getting started is not easy, working with renewable energy in the developing world is exciting and well worth the rewards. If you have the desire to become involved, keep pushing for answers. The right opportunity will surely present itself. The need remains huge, with more than 1.5 billion people who live with absolutely no electricity. Bringing electricity to these people can make dramatic changes in their lives, allowing them to educate themselves, start businesses, and improve their standard of living.

Working to give people in the developing world access to electricity is always a two-way street. The people we help have so much to gain by improving their access to education, health care, additional work opportunities, and much more. But *we* gain as much or more from the experience.

Access

Walt Ratterman, SunEnergy Power Corp., 1133 NW Wall Street, Ste. 305, Bend, OR 97701 • 503-922-1548 • Fax: 503-922-1552 • wratterman@sunenergypower.com • www.sunenergypower.com

Midwest Renewable Energy Association • 715-592-6595 • www.the-mrea.org

Solar Energy International (SEI) • 970-963-8855 • www.solarenergy.org

"Get Your RE Start—Courses, Classes & Training Opportunities," Laurie Stone, *HP116*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Disco Madness

The Whys & Wheres of Disconnects

by John Wiles

Sponsored by the U.S. Department of Energy

In the event of an emergency, disconnect switches are used to rapidly disconnect the external power source conductors from the circuits in a building or structure (*National Electrical Code* Sections 690.13; 230.70). A common disconnect of this type is the AC service entrance disconnect for a house. Utilities require disconnects on grid-tied PV systems to protect their workers from possible electrocution.

Disconnects also are required on individual PV components so that power can be interrupted to them during service—including maintenance or repairs. Another option would be to open all of the main power disconnects to remove all power from a building, but disconnects associated with single components can provide a degree of safety without shutting down the entire electrical system (Section 690.15). Be aware that in this case, some circuits in the system will still be energized and may be near de-energized circuits being serviced. The general *NEC* requirements for these disconnects are discussed below, but the local jurisdiction may stipulate something different.

Disconnected Scenarios

Switches, circuit breakers, screw terminals, and bolted connections all fall under the definition of "Disconnecting Means" in Article 100 of the *NEC* (see also *NEC* Section 690.17). To satisfy *NEC* requirements, disconnects must be accessible switches or circuit breakers without exposed, live parts, and rated for the nominal system voltage and available current. They also must plainly indicate whether they are in the opened or closed position.

The *NEC* specifies several types of disconnects, depending on the type of system and components involved.

- Many utilities require a **lockable, open, visible-blade AC disconnect** for the PV system. This disconnect is typically located near the utility's KWH meter. The AC point of connection will require a disconnect on utility-interactive systems [Section 690.64(B)(1)].
- Contrary to the understanding of some inspectors, **there is no requirement for a disconnect at the PV array itself** [690.14(C)(5)]. Such a disconnect serves no safety purpose for the user or PV installer, since a PV array is always energized when illuminated—even if the disconnect were opened.
- A **main DC PV disconnect** is required where the PV DC circuits from the PV array enter the building (Section 690.13; 690.14). On a PV system, the main PV DC disconnect falls into this category if the PV DC conductors penetrate the house. Although batteries are not power generators, they can source energy, so a battery disconnect might also fall into this category.
- A **main AC PV disconnect** is required for cases in which the DC PV circuits do not enter the building, but the AC output of the inverter does. You won't find this requirement explicitly listed in Section 690, but the diagrams show this scenario in detail.
- A **DC inverter maintenance disconnect** is required; more than one may be required if the system has batteries (Section 690.15).
- An **AC inverter maintenance disconnect** is required for utility-interactive inverters (690.15).
- A **battery disconnect** is normally required on off-grid, battery-based PV systems or grid-tied (utility-interactive) PV systems with battery backup. In situations where batteries are located in a separate room or at some distance (5 feet or more) from the inverter and charge controllers, a second disconnect is required at the battery location, and this disconnect is usually merged with an overcurrent protection device.
- **Charge controller input and output disconnects** are required for maintenance on systems with batteries. (690.15)
- Battery-based inverters with generator inputs may also require a **generator disconnect** at the inverter input (690.15). Systems with backup generators will normally require a generator disconnect both outside, at the generator location ("point-of-entry power disconnect"), and inside, near the inverter and other power-processing equipment ("maintenance disconnect").

Although there are two separate requirements for disconnects, in some cases a single disconnect, properly rated and located, may meet both conditions. In other situations, due to equipment placement and the necessity for grouping the maintenance disconnects, two or more disconnects may be needed in a single circuit (690.15).

Location, Location, Location

The original intent of the requirements for PV disconnects was to match them with the existing requirements for the AC service disconnects as established by Article 230. In fact, 690.14 in the 1984 *NEC* referred the reader directly to Article 230, Part F. Unfortunately, most PV installers did not follow this guidance.

In this era, most installers weren't familiar with installing AC service entrance conductors and service disconnects. Energized PV source- and output-conductor roof penetrations were commonplace, and conductors were routed to the main DC PV disconnect just about anywhere in the structure. Complaints from electricians and electrical inspectors prompted a rewrite of Section 690.14 in the *2002 NEC*. In this revised section (which mimics 230 Parts IV & V), the requirement was firmly established to install the PV disconnect in a readily accessible location at the point where the PV conductors first penetrate the structure. This requirement effectively keeps the energized PV conductors outside the structure until reaching that disconnect. Emergency response personnel assume that when the meter is removed, or when the main AC disconnect is turned off, that all electrical circuits inside a house or other structure will be de-energized ("dead"). If energized ("live") AC or DC circuits are in the house and are not affected by the main

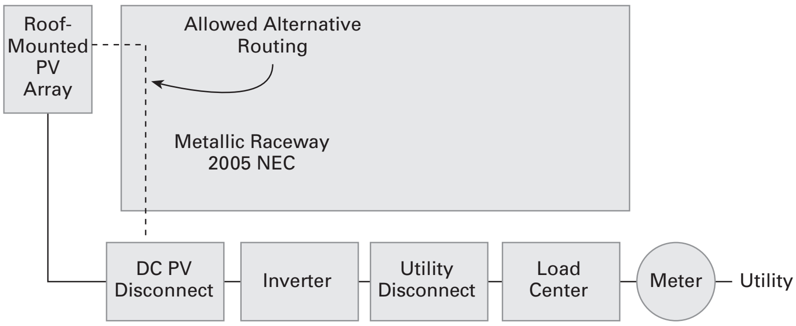

Fig. 1 shows the simplest configuration of a utility-interactive PV system in which the local jurisdiction requires all disconnects to be located outside the building. In this situation, the AC load center and inverter are also both mounted on the outside of the building.

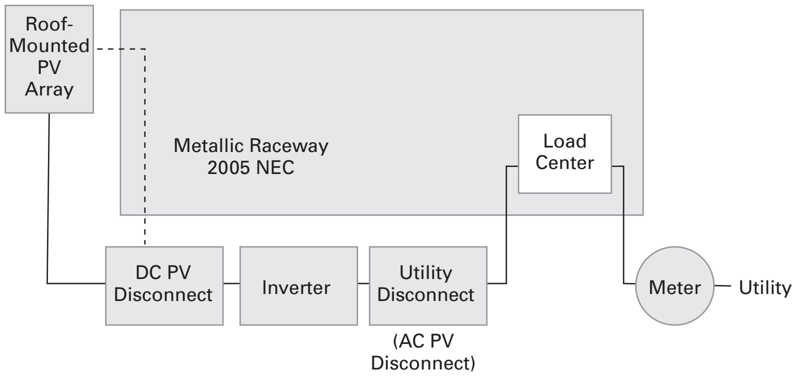

Fig. 2 shows the main load center, with backfed PV circuit breaker, inside the building. In places where an external disconnect (usually lockable open) is required, the utility may also allow this disconnect to be used as the grouped AC maintenance disconnect for the inverter. If a utility disconnect is not required or it cannot be used as a code-required maintenance disconnect, then a separate AC disconnect needs to be mounted in this circuit next to the inverter on the outside of the building.

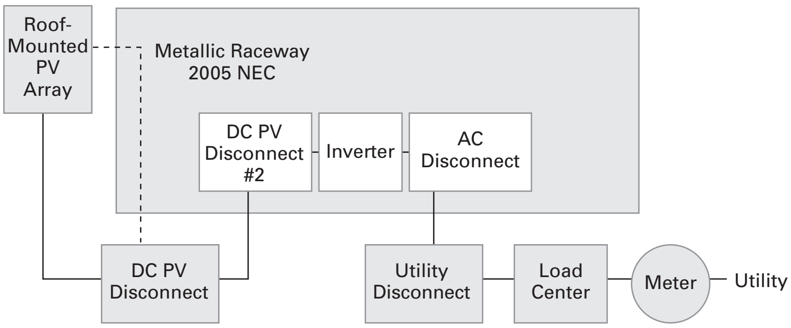

Fig. 3 reflects situations for which the local jurisdiction requires that the main AC and DC power disconnects (and the main load center containing them) be located outside the building, but for architectural reasons, the inverter be located inside the building. To provide for safe maintenance of the inverter, additional DC and AC maintenance disconnects are needed inside the building at the inverter.

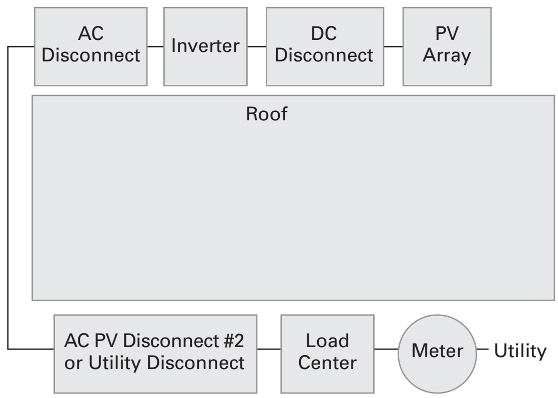

Fig.4 All of the equipment is outside the building for this system. In some roof-mounted PV installations, the inverters are mounted in not-readily-accessible locations near the PV arrays. Section 690.14(D) addresses these systems, and requires AC and DC disconnects at the inverters and an additional AC PV disconnect at ground level.

disconnect, then there is an electric shock hazard for these emergency response personnel.

The *NEC* does not specify whether the main AC service disconnect or the main DC PV disconnect should be located inside or outside the structure at the point of penetration of these circuits. That is left to the local jurisdiction—and the requirement for locating these disconnects varies throughout the country.

Section 690.31(E) of the *2005 NEC* allows the PV source and output conductors to be routed inside the building (represented by the dotted line in the figures) before they reach the main PV disconnect, but only if they are installed in a metal raceway, which include rigid and flexible metal conduit. Metallic cable assemblies, such as and Type MC and Type AC cables, are not allowed yet.

Prescription for Disco Madness

Properly rated disconnects are required throughout a PV system in the code-required places. As the system complexity increases, with batteries, generators, and possibly wind- or microhydro-power inputs, the number of disconnects also increases. But the basic disconnect requirements were in the code long before PV systems arrived, and following those requirements as well as the newer requirements for PV systems will make for safe installations.

Other Questions or Comments?

If you have questions about the *NEC* or the implementation of PV systems that follow the requirements of the *NEC*, feel free to call, fax, e-mail, or write me at the location below. See the SWTDI Web site (below) for more detailed articles on these subjects. The U.S. Department of Energy sponsors my activities in this area as a support function to the PV industry under Contract DE-FC 36-05-G015149.

Access

John C. Wiles, Southwest Technology Development Institute, New Mexico State Univ., Box 30,001/ MSC 3 SOLAR, Las Cruces, NM 88003 • 505-646-6105 • Fax: 505-646-3841 • jwiles@nmsu.edu • www.nmsu.edu/~tdi

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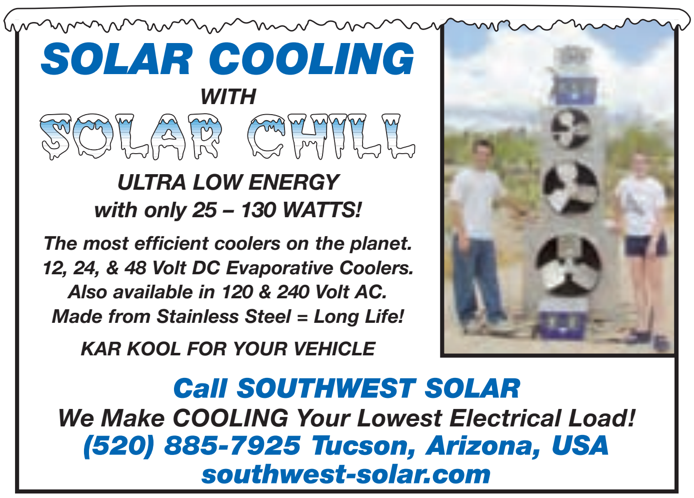
The *2005 National Electrical Code* and the *NEC Handbook* are available from the National Fire Protection Association (NFPA) • 800-344-3555 or 508-895-8300 • www.nfpa.org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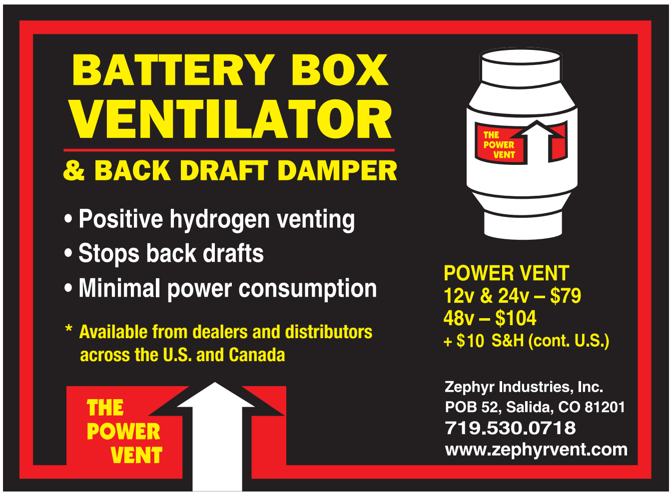
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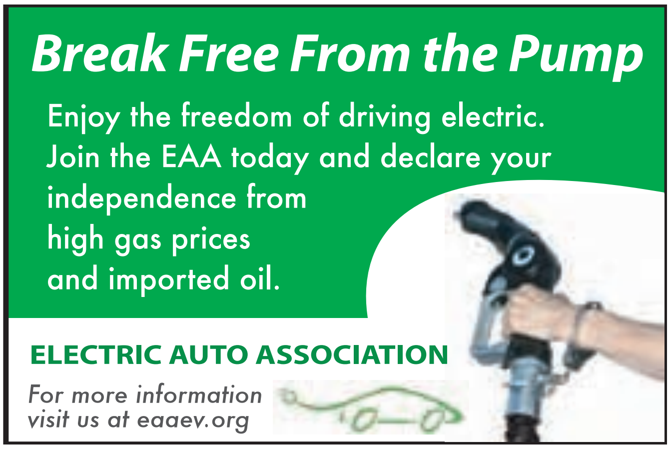
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Belaboring PV Installations

by Don Loweburg

The limited availability of silicon and the subsequent increase in photovoltaic (PV) module prices have constrained the growth of solar-electric installations, both in the United States and globally. But a recent easing of the silicon shortage is expected to reverse the two-year-long increase in module prices.

A recent survey by Solarbuzz, an international solar energy research and consulting company (see Access), suggests that retail prices for PV modules are leveling off and maybe even beginning to decline. Although this will be a boon to the continued growth in the installation of PV systems, another near-term constraint is appearing—the availability of qualified workers to install these systems.

One recent change in the U.S. PV market that affects the installation workforce has been a shift in the "typical" PV consumer. In 2005, the installation of commercial-scale (100 KW and greater) PV systems surpassed that of residential installations. This trend continues today, and is based on both economies of scale available when modules are purchased in large quantities and the fact that federal tax law favors business investment in solar-electric systems.

A recent report on the state of the U.S. solar industry by the Prometheus Institute indicates about 30 megawatts (MW) of residential PV was installed in 2006, while commercial (large) systems exceeded 50 MW. With the number of installed PV systems in the United States growing by about 20 percent annually, there will be a continued need for additional PV installers both for large and small systems.

In the meantime, how are PV installation companies currently responding to the expected upturn in business? And how can businesses continue healthy, profitable development, while expanding their labor pool?

Seeking Solar Staff

Although the number of PV installations has increased in the United States, these installations are not evenly distributed within the states. Four states—California, New Jersey, New York, and Arizona, all with strong financial incentive programs—account for 96 percent of the total number of commercial and residential PV systems installed in 2006. In these states, overwhelming demand is outpacing the workforce. A casual survey of several PV installing companies' Web sites reveals that, in general, both small and large companies are hiring and expanding installation capability. Staffing demand in all skill categories is high, ranging from laborers to designers, sales staff, and business managers.

Meeting labor needs is becoming a challenge for most installing companies, no matter what their size. How are companies meeting these needs? Small companies that have only a handful of employees are hiring through word of mouth and often providing on-the-job training. Smaller companies are also networking and, when needed, passing customers to one another. Often this is done as a courtesy or for a small commission.

Larger companies are recruiting employees via their Web pages and other channels, such as placement agencies. For them, the hiring specifications are fairly explicit. Often requirements include formal corporate-level business experience, contractor licensing, and, in some cases, engineering degrees. These job requirements may also specify certification by the North American Board of Certified Energy Practitioners (NABCEP), an organization that establishes national certification standards for renewable energy professionals.

Boosting Educational & Training Efforts

In response to the increasing demand for PV installers, several renewable energy education organizations, like Solar Energy International, the Midwest Renewable Energy Association, and the Solar Living Institute, have expanded their course offerings. The International Brotherhood of Electrical Workers (IBEW) also has developed a number of programs and projects to train their members.

The increasing demand for installers is also clearly indicated by an upsurge in the number of qualified test applicants applying for NABCEP's PV Installer certification. This year, the number of qualified test applicants is estimated to exceed those in 2006 by about 80 percent, and the number of NABCEP-certified installers is projected to increase by 50 percent.

Forward to the Future

The continued growth in the demand for PV installations, driven in part by government incentives coupled with a silicon supply increase, will continue to stimulate the demand for qualified PV installers in the United States. The need is increasing for all applications, including residential

retrofits, new housing, and commercial buildings. Each of these sectors will need competent installers. Opportunities exist for employment at all levels, whether they are small independent shops, larger companies with multiple branches, or union contractors working on large commercial projects. Knowledge and competency will continue to be in high demand and the PV industry needs to support training programs and certification that will assure continued availability of a competent workforce.

Access

Don Loweburg • don.loweburg@homepower.com

Sources:

Prometheus Institute for Sustainable Development • www.prometheus.org

Renewable Energy Access • www.renewableenergyaccess.com

Solarbuzz • www.solarbuzz.com • Details on PV module prices & other industry information

Additional Information:

Interstate Renewable Energy Council • www.irecusa.org • Workforce Development Project information

Solar Speculation or Solution?

by Michael Welch

A new company in the solar industry is promising to completely change the face of the residential solar-electric market. How? By leasing rooftop PV systems to homeowners and eliminating the sizable investment required to purchase a system to generate all of a home's electricity needs.

Solar for Rent

Citizenre's prospective REnU program would provide grid-tied PV systems at no up-front cost to homeowners. Homeowners in states with net metering would sign a "Forward Rental Agreement" with Citizenre, renting their rooftop PV systems for a specified time frame (1, 5, or 25 years) and pay a fixed rate, at or below their current electricity price, for the electricity generated over the lease agreement's lifetime. In turn, Citizenre promises to engineer a grid-tied PV system that will meet the homeowner's electricity needs. Once the system is installed, homeowners receive a monthly bill from Citizenre for the electricity used. Besides a $500 deposit (due when the company is ready to start installing), there's no other initial cost involved. Citizenre customers agree to pay the per-KWH rates and give the company access to the system for the period of the contract. This is very close to what many solar energy supporters, who have the desire but not the funds to install a PV system, have been waiting for—rooftop PV systems that are affordable from the beginning, and that can even generate electricity below utility retail rates, if these rates rise above the contract-signed fixed rate.

The State of REnU

Originally, Citizenre's president, David Gregg, had targeted a goal of 100,000 customers by early 2008. So far, about 12,000 prospective customers have signed up for the REnU program. The company, however, still has ambitious plans to manufacture, market, and install PV systems. So how do they plan to get from here to there?

Citizenre says that they have obtained $650 million in financing to make their idea a reality. With that money, they say they will build their own new PV module manufacturing facility, and manufacture their own specially designed inverters and remote system-monitoring equipment so they can track the systems' production and households' energy usage. This or other funding would also be used to finance the cost of the systems.

Citizenre is also relying on a multilevel marketing business model to recruit sales associates, which means that individuals join with a parent company in a franchise relationship, and they get paid a percentage of the sales they make. If they bring in other franchisees, they get a percentage of their sales as well. So the top level of folks make the most money, as the percentages of the sales from all the levels of franchisees work their way up the ladder to the top. To date, almost 1,000 associates have signed on to Citizenre's Powur Plan. It's important to note that these sales associates are banking on the success of the program, and future profits, once systems begin to be installed. To date, they have received no financial compensation.

Shaking Up the Industry

In a March 2007 interview with National Public Radio's Jim Zarroli, Gregg said that Citizenre is "here to help commercialize PV and to help bring it to the forefront; hopefully make it one of the major contributors to our energy mix."

Despite Gregg's optimism, some seasoned solar professionals are skeptical that Citizenre can deliver on all that it has promised.

The very success of their marketing efforts thus far has some industry folks very concerned. Homeowners who had been considering purchasing their own PV systems are postponing their decisions, hoping that the Citizenre model will save them the tens of thousands of dollars that a PV system can cost—and who can blame them? This past spring, I attended a local church congregation's meeting where they considered PV system recommendations from the church's Green Sanctuary Committee. They obtained an estimate for the PV system they were planning, and were looking for approval to spend the money and do some fundraising. One of the members had heard of "free systems" available, and was suggesting that the congregation did not need to spend the money to purchase a system outright. However, the rest of the congregation saw more value in a bird in hand over one in the bush—and agreed to spend the money to purchase and install a system, pending investigation into the availability of a "free" system.

At this writing, Citizenre's Web site states that in the beginning of 2008, its PV systems will be available to franchises for installation for customers who registered earliest. The challenge? That leaves a too-short time to get their manufacturing facility up and running—and producing PV modules and components. But the same Web page

mentions, "We want to make very clear that the location of Citizenre's manufacturing facility is still in negotiation. And, as with all scheduling, delays can occur." And it's this discrepancy that's giving industry insiders pause. Jeffrey Wolfe, CEO of groSolar and long-time PV industry watcher, believes that it would take at least eighteen months for a PV manufacturing facility to come on line. According to Rob Wills, Citizenre's Chief Technical Officer, an announcement for the groundbreaking for the plant was due mid-March, but did not come.

Other skeptics question Citizenre's profitability plan—the cost of the systems versus the payback that the company's investors might expect. According to renewable energy (RE) integrator Todd Cory, the figures just do not make sense. He says that a typically inefficient U.S. home uses 35 KWH per day. The PV system needed would be 7 peak KW, which could cost up to $60,000 without incentives. At $0.10 per KWH (close to the U.S. average for retail electricity rates), it would take nearly 47 years to achieve simple payback on the system. But Citizenre says it will be able to reduce material costs by vertical integration and economies of scale, and "be able to produce the final product at half the cost of our competitors." Based on current retail utility rates, this would lower the simple payback to about 23 years. Even if the company can get the costs down that low and still make a profit, Cory questions why Citizenre's investors would invest in something that could take such a long time to produce returns on their money.

Wolfe sees two additional issues with Citizenre's approach. In a February 2007 *Renewable Energy Access* article, he wrote, "Rob Wills indicated that Citizenre has a source for silicon at 'significantly below $60 per kilogram.' My opinion is that when established international PV companies like Schott Solar cannot obtain sufficient silicon, there is no way for an unproven start-up to obtain silicon, and certainly not at below-market prices."

Wolfe went on to comment, "Unfortunately, the price of solar power is not purely a function of volume production. Glass, aluminum extrusions, Tedlar, and lead wires are all commodity products, but all comprise a significant piece of the cost that Citizenre cannot affect. To think that a start-up is going to beat world leaders like Sharp, Kyocera, and Suntech (that are currently producing at scale) is naive. What technology is Citizenre planning on using? With more knowledge, we can then understand the probable costs of the technology for comparison purposes."

Pricing Must Come Down

For many years, I have been waiting for the price of solar-electric systems to come down. There has been a long-term downward trend, but prices haven't dropped nearly as much as many have hoped. The magic price-break for PV modules—when solar-generated electricity can compete with utility retail rates—has long been thought to be around $2 per peak watt. When that price is achieved, installed system prices should go down remarkably, approaching what Citizenre is projecting. Whether we get there with Citizenre's leasing program, or by other means like long-term incentives, there will come a time when Citizenre's financing plan of paying for systems based on utility savings will be a great tool.

I think there is a lot of merit to this idea, and that eventually it's possible that all solar-electric retailers will be able to finance homeowner-*owned* PV, wind, and solar thermal systems by using rebates and incentives, and paying off the rest with utility savings. This financing method will become closer to reality as PV system costs decrease and utility rates increase.

The world needs a quantum shift in where power comes from, and the sooner renewable energy technologies are widely adopted, the better.

But in the meantime, some RE integrators say that it doesn't pencil out for home-scale installations—yet. There would have to be a big downward shift in the price of PV systems for the plan to pay off. If the price gets that low, affordability will not be nearly the barrier that it is right now—folks could own the systems and pay them off just as if they were paying "rent" on the Citizenre systems. But Citizenre appears to be pinning their hopes on flooding the market before cheaper PV is available to other installing companies.

The world needs a quantum shift in where power comes from, and the sooner renewable energy technologies are widely adopted, the better. Global warming and wars for oil resources are the two biggest reasons why folks are excited about RE in general, and about the Citizenre program. But if it turns out their promises are something that cannot be fulfilled, the level of disappointment and distrust could leave public perception of the RE industry with a black eye that might take years to overcome, with the net result being worse than if Citizenre had never shown up in the first place.

Access

Michael Welch, c/o Redwood Alliance, PO Box 293, Arcata, CA 95518 • 707-822-7884 • michael.welch@homepower.com • www.redwoodalliance.org

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Watts & Watt-Hours

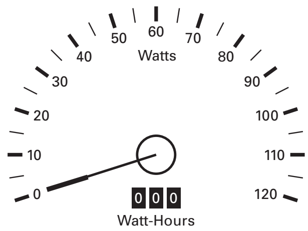
Making Sense of Power & Energy

by Ian Woofenden

Derivation: The watt as a unit (technically one joule per second) was originally proposed in 1882 to honor James Watt, a British engineer who invented an improved steam engine, and coined the term "horsepower."

When Americans measure how fast and how far a vehicle is traveling, we use a rate of miles per hour and a quantity of miles. When we measure water flowing, it's in gallons per minute and gallons. When we measure electrical energy use, the *rate* is *watts* and the *quantity* is *watt-hours.*

If you don't know the difference between a mile and a mile per hour, you'll never understand distance and speed. Get the basic distinction between watts and watt-hours into your head and you'll be on your way to understanding how you use electrical energy in your home—and how to reduce the waste.



Watt = Rate of Energy Use
Watt-Hour = Quantity of Energy

A typical inefficient American home uses the energy equivalent of between 25,000 and 100,000 watt-hours (25–100 kilowatt-hours; KWH) of electricity each day, depending on its size, number of occupants, location, heat source, etc. Most analyses show that heating and cooling use 45 to 55 percent of a home's energy. Water heating comes in second, using 13 to 21 percent. Refrigeration may use 5 to 8 percent, lighting 7 to 10 percent, and other appliances and electronics, 20 to 30 percent.

But what's more important than where the energy goes in some fictitious "typical" home is where it goes in *your* home. And there's nothing you can read here that will tell you that—you need to measure it!

To measure electrical energy usage of appliances in your home, you need a meter that measures watts and watt-hours. Several manufacturers make such meters, including popular brands such as the Kill A Watt meter from P3 International, the Watt's Up meter from Electronic Educational Devices, and the Digital Power Meter from Brand Electronics.

Buy one of these meters today, and you can begin to sleuth out where your electricity dollars are going—appliance by appliance. Plug your meter into a wall socket, and start checking appliances with it. Read the watts display, and you will see the rate of energy use for the appliance you're testing. If your TV is drawing 10 watts even when its power switch is off, it's using 10 watt-hours per hour, or 240 watt-hours per day. (See Joe Schwartz's article on phantom loads in *HP117* for more information about how to identify and eliminate small, hidden loads like this.)

For any electrical load with a constant energy draw, you can measure the wattage and then multiply by the hours of use. For instance, if your favorite desk lamp draws 20 watts (you've already upgraded to an efficient compact fluorescent bulb) and you use it four hours a day, the energy load is 80 watt-hours per day.

Appliances that cycle on and off—such as your refrigerator, washer, or coffee maker—take a different approach. Plug the appliance into the meter and leave it for a few days or a week. When your test period is done, divide the KWH consumed by the hours the appliance was plugged into the meter, and multiply by 24 to get KWH per day. Then visit the American Council for an Energy Efficient Economy and Energy Star Web sites for energy-efficient appliance electrical consumption, so you can decide whether it's time to upgrade your appliances to more efficient ones.

If you want to get a handle on our home's energy usage, understanding the difference between a watt and a watt-hour is the first step. Then you need to buy a meter and get to work on finding out where your watt-hours are going. Determined homeowners can cut their energy use by one third or more by implementing energy efficiency and conservation measures. Give yourself a goal to reduce your energy use, and start identifying and eliminating those wasteful watt-hours today!

Access

Ian Woofenden, PO Box 1001, Anacortes, WA 98221 • ian.woofenden@homepower.com

American Council for an Energy Efficient Economy • www.aceee.org

Energy Star • www.energystar.gov

"Finding the Phantoms: Eliminate Standby Energy Loss," Joe Schwartz, *HP117*

Watt/Watt-Hour Meters:

Digital Power Meter • Brand Electronics • www.brandelectronics.com

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Talk the Walk

by Kathleen Jarschke-Schultze

Throughout the years, as travel and schedule have allowed, I have given renewable energy (RE) presentations at my nieces' schools. In their early school days, it would be a short solar cooking demonstration with an assortment of solar cookers and a brief Q&A session beforehand. In the third and fourth grades, sun-baked muffins were the big hit.

When the girls went to a charter school instead of a public junior high, the presentations became more focused on RE for the home and related environmental issues—the kids were older and had longer attention spans to absorb this information.

When I do a presentation these days, I bring a lot of photos on a CD or memory card to illustrate my RE-based lifestyle and show the technology at work. The only real planning I do is to edit the photos I've gathered so far, and add or delete ones according to their relative interest level for teenagers.

New Tech Gets RE Tech

My 16-year-old niece Anna now attends New Tech High in my hometown of Napa, California. While covering the usual high school subjects for grades 9 through 12, there is an attention to technology and science, so covering RE topics is a natural fit.

Anna took me to the front office, where I signed in and received a visitors badge. I was going to address the Environmental Studies class, which was made up of mostly juniors and seniors. Being New Tech High, there was no problem hooking up my memory card to a computer's reader to get my presentation rolling.

Talking Head

I work without notes, and as each slide comes up I talk about what is pictured and any related story I can attach to it. I learned early on in public speaking that your audience will enjoy and remember your information more if you couch it in a story. After being introduced to the kids, I told them to interrupt me at any point with any questions that came to mind.

I always start with a picture of snow-covered Mt. Shasta and explain how, although I grew up in Napa, I now live at the top of the state. The next picture is of Soda Mountain, at the top of the small canyon where my husband Bob-O and I live. This leads me into an explanation of the thermal flywheel effect of having a cold mountain at the head of our canyon and, some 10 miles downslope, a relatively warm reservoir. I explain how we take advantage of these winds that funnel through our valley with a wind turbine, which produces some of our household electricity.

My audience is then set up to view a diagram I have drawn in a graphics program of our homestead. It shows the placement of our solar-electric (photovoltaic; PV) modules that produce electricity for the house and for water pumping. It also shows where Camp Creek and our microhydro turbine, with its length of pipe, are situated relative to the house. Our wind turbine sits in the meadow just north of our home. The diagram helps give context for the next group of slides I show.

Rural Roots

I run through the pictures of our homestead, and explain how our garden, small vineyard, and orchard are watered by solar-pumped water. I also show how I dry our garden largesse in the solar greenhouse attached to the house, how our kitchen compostables go into the solar composter or my old bathtub that serves as a worm bed under the apple tree. This leads to slides of crushing and pressing our homestead-harvested apples into fresh apple juice.

The slides so far illustrate our off-grid lifestyle on our rural homestead and how much we do for ourselves in terms of producing our own energy and growing our own food. Besides photos of our high-tech gear and low-tech gardens, I have one slide that always elicits an audible response. It is of a rattlesnake my friend Katcha found in her yard swallowing a rabbit. I assure them it is a rabbit and not a cat, as it is hard to tell. I tell the kids that we see three to nine rattlesnakes a year in our yard during hot weather. We have unknowingly walked over them on the porch steps, found them coiled around the vise in the carport, and surprised one in the

doorway to the greenhouse. This is also part of living in the remote countryside.

The last half of the slides are of off-gridders I know who live with RE, and of the RE systems themselves. There are young couples just starting out and older retired couples, both beyond the grid. I talk about how some people build a power shed, which holds the inverters and batteries, and put the PVs on the roof. They then use the solar electricity generated to run power tools for building their homes.

This leads me into one of my favorite stories. My husband Bob-O, who installs RE systems for a living, had an off-grid client who had hired contractors to build his house while Bob-O installed the system. The contractors had been using generators to run their power tools. When Bob-O finished the system, he told the builders where they could plug in to run their tools off solar power. After listening to Bob-O's explanation of the PV system's operation, one of the workers asked, with a straight face, "So if I turn on my circular saw, will the sun dim?"

Quick on his feet, Bob-O replied, "Yes, but only for a nanosecond—you won't notice it." It did take awhile for the kids to get the joke, but the teacher got it right away.

The Future is Now

These days, there are an increasing number of grid-tied systems in my slide show. One of the more interesting ones to the students is of the Wilderness Charter School in Ashland, Oregon. Several slides show volunteers mounting the PV modules on the roof. A picture of the grid-tie inverter next to the utility power meter completes that section.

I explain to the kids the benefits of generating electricity with the sun, wind, and water at home. We discuss conservation measures they could practice in their homes now. I tell them that using compact fluorescent lights and turning off electrical appliances and electronics when not in use are the most obvious actions they could employ.

I left a couple of bumper stickers stating, "Renewable Energy Is Homeland Security." I was pleased I didn't have to explain the sentiment. I heard from my niece the next day that all the kids want bumper stickers and they all want to live my lifestyle. Having been to my home, Anna related to them the hour drive to get to any town, which dampened some of the kids' enthusiasm for the remote life. But their interest in renewables remained and that's the important thing.

New Tech High now has a committee of juniors and seniors looking into outfitting their school with a solar-electric system. They are applying for a grant from Pacific Gas & Electric, their local utility. I believe the awareness about solar electricity and renewables in general is growing. I'm hoping my presentations show the kids it is happening right now, anywhere the sun shines.

While having dinner with my siblings' families, Mike, my next-oldest brother, asked me to give a solar cooking demonstration at my youngest nephew Gavin's elementary school. Now that Gavin's older brother Derek goes to the same charter school the girls did, it seems like I'll be back there too.

Just talking to young people about the importance and accessibility of renewables makes me feel good, like I am doing just a bit more for the future—our future, their future. Through the years, my young audiences have become more accepting, less astounded, and certainly more eager to use the technologies available now.

If you ever have the chance to share your knowledge of RE with kids of any age, do it. It's like voting—it's just the right thing to do.

Access

Kathleen Jarschke-Schultze is constructing a shaded area for growing lettuce at her home in northernmost California. c/o *Home Power* magazine, PO Box 520, Ashland, OR 97520 • 800-707-6585 • kathleen.jarschke-schultze@homepower.com


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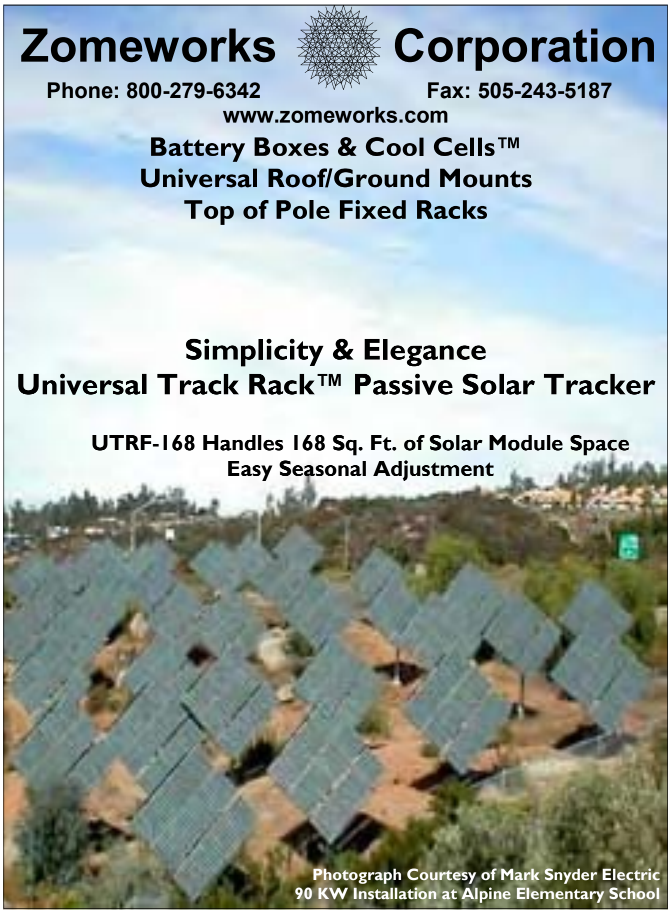
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Oct. 6, '07. National Tour of Solar Homes. Tours in most states. Info: American Solar Energy • www.ases.org

ARIZONA

Jul. 9–Aug. 3, '07. Prescott, AZ. Building & experimenting with new & old materials & methods. Ecosa Institute • 928-541-1002 • info@ecosainstitute.org • www.ecosainstitute.org

CALIFORNIA

Jun. 18–20, '07. Long Beach, CA. PV Summit. Assessing markets & advancements in PV. Info: Intertech-Pira • 207-781-9603 • dsanborn@intertechusa.com • www.intertechusa.com/pv

Jul. 11–Aug. 15, '07. Davis, CA. LEED Building Certification. Public workshop Aug. 16. Info: UC Davis Extension • 800-752-0881 • info@unexmail.ucdavis.edu • www.extension.ucdavis.edu

Sep. 24–27, '07. Long Beach, CA. Solar Power 2007. Conference & expo. Info: 202-396-1688 ext. 2 • ebrown@solarelectricpower.org • www.solarpowerconference.com

Arcata, CA. Workshops & presentations on RE & sustainable living. Campus Center for Appropriate Technology, Humboldt State Univ. • 707-826-3551 • ccat@humboldt.edu • www.humboldt.edu/~ccat

Hopland, CA. Workshops on PV, wind, hydro, alternative fuels, green building & more. Solar Living Institute • 707-744-2017 • sli@solarliving.org • www.solarliving.org

COLORADO

Carbondale, CO. Workshops & online courses on PV, water pumping, wind, RE businesses, microhydro, solar domestic hot water, space heating, alternative fuels, straw bale, green building, women's PV courses & more. Solar Energy Intl. (SEI) • 970-963-8855 • sei@solarenergy.org • www.solarenergy.org

FLORIDA

Jun. 3–6, '07. Cape Canaveral, FL. Renewables: The Road to Sustainability. Program on sustainable applications for tropical isles. Info: 321-638-1443 • young@fsec.ucf.edu • www.caribbeansolar.org

Melbourne, FL. Green Campus Group meets monthly to discuss sustainable living, recycling & RE. Info: fleslie@fit.edu • http://my.fit.edu/~fleslie/GreenCampus/greencampus.htm

INDIANA

Jun. 2–3, '07. Muncie, IN. Living Lightly. Resource fair for sustainable lifestyles. Workshops on alternative building, RE, alternative transportation & more. Exhibits, vendors, field trips, music, kids' programs, more. Info: www.livinglightlyfair.org

IOWA

Iowa City, IA. Iowa RE Assoc. meetings. Info: 319-341-4372 • irenew@irenew.org • www.irenew.org

MASSACHUSETTS

Hudson, MA. Workshops: Intro to PV; Advanced PV; RE Basics; Solar Hot Water & more. The Alternative Energy Store • 877-878-4060 • support@altenergystore.com • http://workshops.altenergystore.com

MICHIGAN

Jun. 22–24, '07. Onekama, MI. Michigan Energy Fair. Exhibits, vendors & workshops on green building, solar architecture, wind energy, energy efficiency, alternative fuel vehicles & more. Music & food. Info: Great Lakes RE Assoc. • 800-434-9788 • info@glrea.org • www.glrea.org

West Branch, MI. Intro to Solar, Wind & Hydro. 1st Fri. each month. System design & layout for homes or cabins. Info: 989-685-3527 • gotter@m33access.com • www.loghavenbbb.com

MINNESOTA

Jun. 8–9, '07. Grand Marais, MN. Small Footprint Living Fair. RE, green building, more. Info: Cook County Community Center • 218-387-3015 • diane.booth@co.cook.mn.us

MISSOURI

Sept. 22–23, '07. Columbia, MO. Ozark Renewable Energy & Sustainable Living Expo. Info: www.ozarkre.org

New Bloomfield, MO. Workshops, energy fairs, and other events. Missouri Renewable Energy • 800-228-5284 • info@moreenergy.org • www.moreenergy.org

MONTANA

Whitehall, MT. Seminars, workshops & tours. Straw bale, cordwood, PV & more. Sage Mountain Center • 406-494-9875 • www.sagemountain.org

NEW HAMPSHIRE

Rumney, NH. Green building workshops. Info: D Acres • 603-786-2366 • info@dacres.org • www.dacres.org

NEW MEXICO

Six NMSEA regional chapters meet monthly, with speakers. NM Solar Energy Assoc. • 505-246-0400 • info@nmsea.org • www.nmsea.org

NORTH CAROLINA

Boone, NC. Western NC RE Initiative '07 workshops: SDHW; Community-Scale Biodiesel Production; PV & the Code; Solar Space Heating; Small-Scale Wind Installation & more. Info: Appalachian State Univ. • 828-262-2933 • wind@appstate.edu • www.wind.appstate.edu

Saxapahaw, NC. Solar-Powered Home workshop. Solar Village Institute • 336-376-9530 • info@solarvillage.com • www.solarvillage.com

OHIO

Jul. 7–12, '07. Cleveland. Solar 2007, annual ASES conference. American Solar Energy Society • 303-443-3130 • ases@ases.org • www.ases.org

OREGON

Jul. 25–26, '07. John Day, OR. The Whole-House Workshop. Pre-SolWest workshop: an architectural decision-making process. Info: See EORenew listing that follows.

Jul. 27–29, '07. John Day, OR. SolWest RE Fair. Exhibits, workshops, speakers, family day, music, alternative transportation & Electrathon rally. EORenew • 541-575-3633 • info@solwest.org • www.solwest.org

Cottage Grove, OR. Adv. Studies in Appropriate Tech., 10-week internships. Aprovecho Research Center • 541-942-8198 • apro@efn.org • www.aprovecho.net

PENNSYLVANIA

Philadelphia Solar Energy Assoc. meetings. Info: 610-667-0412 • rose-bryant@verizon.net

RHODE ISLAND

Jun. 9, '07. Coventry, RI. Sustainable Living Festival & Clean Energy Expo. Info: Apeiron Inst. • 401-397-3430 • info@apeiron.org • www.livingfest.org

TENNESSEE

Summertown, TN. Workshops on PV, alternative fuels, green building & more. The Farm • 931-964-4474 • ecovillage@thefarm.org • www.thefarm.org

TEXAS

El Paso Solar Energy Assoc. Meets 1st Thurs. each month. EPSEA • 915-772-7657 • epsea@txses.org • www.epsea.org

Houston RE Group quarterly meetings. HREG • hreg@txses.org • www.txses.org/hreg

WASHINGTON STATE

Jul. 21. '07. Shoreline, WA. Shoreline Renewable Energy Fair. Info: www.shorelinesolar.org

Guemes Island, WA. SEI 2007 workshops. Oct. 6: Intro to RE; Oct. 8–13: Solar-Electric Design & Installation; Oct. 15–17: Grid-Tied Solar Electricity; Oct. 19–20: Successful Solar Businesses; Oct. 22–24: Solar Hot Water; Nov. 5–10: Electric Vehicle Conversion. Info: See SEI in Colorado listing. Local coordinator: Ian Woofenden • 360-293-5863 • ian.woofenden@homepower.com

WISCONSIN

Jun. 12–13, '07. Custer, WI. Small Wind Power Conf. Wind turbine companies, test results, zoning & permitting processes, dealers & installer concerns. Info: Amy Heart, see MREA listing that follows.

Jun. 15–17, '07. Custer, WI. RE & Sustainable Living Fair (aka MREF). Exhibits & workshops on solar, wind, water, green building, alternative transportation, energy efficiency & more. Home tours, silent auction, Kids' Korral, entertainment, speakers. Info: See MREA listing below.

Custer, WI. MREA '07 workshops: Basic, Int. & Adv. RE; PV Site Auditor Certification Test; Veg. Oil & Biodiesel; Solar Water & Space Heating; Masonry Heaters; Wind Site Assessor Training & more. MREA • 715-592-6595 • info@the-mrea.org • www.the-mrea.org

INTERNATIONAL

COSTA RICA

Jan. 21–27, '08. Rancho Mastatal. RE for the Developing World. Hands-on workshop. Info: See listing for WA State.

FRANCE

St. Laurent de Cerdans. Solar Electricity Design Course: Jun. 11–15 & Sep. 10–14; Intro to RE: Jun. 4–8 & Sep. 3–7. Info: Les Amis de Numero Neuf • info@lesamis9.org • www.lesamis9.org

GERMANY

Jun. 21–23, '07. Freiburg. PV Industry Forum 2007 & Intersolar 2007. PV markets forum followed by solar developments exhibition & forum. Info: www.pvindustry.de & www.intersolar.de

ITALY

Sep. 3–7, '07. Milano. European PV Energy Conference & Exhibition. Info: WIP Renewable Energies • 49-89-720-127-35 • pv.conference@wip-munich.de • www.photovoltaic-conference.com

NICARAGUA

Jul. 29–Aug. 9, '07. Managua. Solar Cultural Course. Lectures, field experience & ecotourism. Richard Komp • 207-497-2204 • sunwatt@juno.com • www.grupofenix.org

SPAIN

Jun. 26–28, '07. Madrid. RE Europe. Future RE technologies & concepts. Info: REE • 44-0-1992-656-632 • aijaz@pennwell.com • www.renewableenergy-europe.com

WALES

Aberystwyth. RE workshops. Jun. 11–15 & Sep. 10–14: PV Installation; Oct. 19–21: Wind & Solar; Oct. 23–24: RE for Planners; Oct. 26–28: Intro to RE. Info: Green Dragon Energy • 49-0-30-486-249-98 • info@greendragonenergy.co.uk • www.greendragonenergy.co.uk

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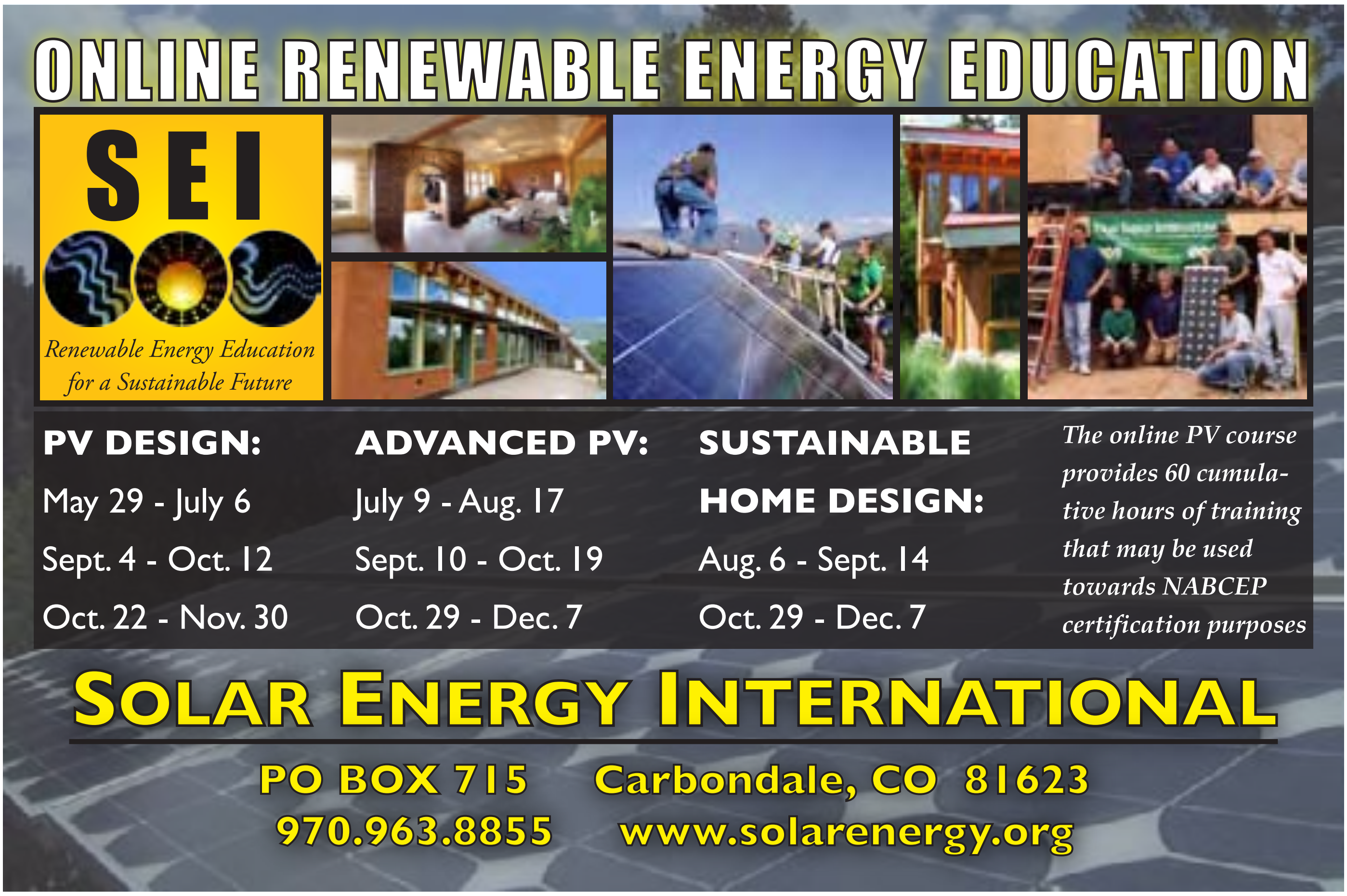
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RE People

Who: Ginny Wolff & Ray Minnerly
Where: Burlington, Washington
When: 2006
What: Grid-tied solar-electric system
Why: Environmental ethics

Ray and Ginny in front of their grid-tied home in Washington.

Ginny Wolff echoes the thoughts of many people who want to feel better about where their energy comes from: "I have been interested in switching to renewable energy ever since I realized that much of the electricity and heat that makes our lives convenient comes from fossil fuels and nuclear plants."

Ginny and her partner Ray Minnerly moved to Washington's Skagit Valley from Minnesota in the '90s. Ray is an electrical engineer at Fluke Networks. Ginny is a retired family physician who now spends her time gardening, playing music, and working as a social–political activist.

Both Ginny and Ray love spending time outdoors, whether it's tending their organic garden or watching wildlife from the bow of their 30-foot sailboat. Their first forays into solar and wind energy were installing small systems on their boat, which allowed them to comfortably live aboard for sixteen months. Seeing how easily the sun and wind provided energy for their boat's electric appliances helped them decide to buy a solar-electric (PV) system for their home.

To set the stage for the system installation, Ginny and Ray first made some changes to reduce their household energy use. These measures included turning down the thermostats for space and water heating, hanging clothes to dry on a clothesline instead of using the electric dryer, and switching to compact fluorescent lightbulbs instead of using incandescents.

The solar- and wind-powered sailboat is Ray and Ginny's home away from home.

Courtesy Ginny Wolff (2)

A shade-free rooftop on the garage provided a perfect place for the PV array.

In September 2006, Dana Brandt of Eco-Tech in Bellingham, Washington, installed a 2.9-kilowatt PV system, using Sharp modules and a Xantrex batteryless grid-tie inverter. Ginny and Ray had decided that they could afford about $25,000 for the system, which was designed to supply a large portion of their home's electricity. The PV array was installed on the garage roof—a highly visibly location to neighbors and passersby—and the proud owners are happy to answer questions about it.

Ginny says, "We have to find a way for humans to live on this planet without destroying it, if there is going to be any hope for our kids. As a society, we need to make the political decision to support sustainable energy resources, instead of subsidizing the oil industry. We need transportation alternatives that aren't dependent on carbon dioxide-producing fossil fuels, and industrial technology that doesn't destroy the environment. Installing a PV system was a little place for us to start, with the hope that ideas will catch on and people will begin to change the ways they think about and use energy."

—Ian Woofenden

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